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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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VOL. CVII.—No. 2788.] *LONDON: FRIDAY, JUNE 6, 1919.* [*Registered at the General Post Office as a Newspaper.*] PRICE 9d. [BY INLAND POST ... 11d.

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For Illustrated Advert., see page 6, April 11. 7356

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See page 15. 7451

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See Advertisement page 103, May 30.

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designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED,
Boyne Engine Works, Leeds. Oct 3482
See their Illus. Advertisement, page 147, last week.

Cochran MULTITUBULAR AND CROSS-TUBE TYPES.
Boilers.
See page 17. 7363

RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS,
MOTHERWELL. Oct 3668

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See Advertisement page 123. 7266

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SYPHONIA STEAM TRAPS, REDUCING VALVES
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Yarrow Patent Water-tube Boilers.
6872
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See Full Page Advt., page 93, May 30.

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Walter Somers & Co., Ltd.,
HALESOWEN. 7110

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Forgings, Castings, Bars, Sheets, Wire, Tubes,
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Taylor & Challen Presses.
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See Full Page Advertisement, May 30.

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See half-page Advert., last week and next week. 7328

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
7209
See half-page Advertisement page 108, May 16.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER. Chief Engineer: C. E. STROMEYER, M.I.C.E. Founded 1854 by SIR WILLIAM FAIRBAIRN. Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 7479

Mr. E. M. Munro has ceased

to ACT as REPRESENTATIVE of Messrs. BRECKNELL, MUNRO & ROGERS in London area as from May 31st; he will, however, continue to act in an advisory capacity to the firm.

Mr. A. M. WILLIS has been appointed as Representative of the firm in the London area, and all communications should in future be addressed to our head office in Bristol. W 290

London Association of FOREMAN ENGINEERS.

Established 1852.

Foreman, Managers and Employers connected with the Engineering Industry.

MONTHLY MEETINGS are held at the Cannon Street Hotel, E.C.

Membership is not confined to residents in London.

Secretary:
JAMES HARRINGTON, O 270
86, Salisbury Road, Harrow, Middlesex.

The Yarrow Educational Fund SCHOLARSHIP AND THE WILLIAM LINDLEY BEQUEST SCHOLARSHIP.

THE COUNCIL OF THE INSTITUTION OF CIVIL ENGINEERS are PREPARED to CONSIDER APPLICATIONS for a nomination to these SCHOLARSHIPS.

The Yarrow Educational Fund Scholars must be British Subjects who, desiring to become Engineers, lack sufficient means to enable them to continue their practical or scientific training. The scholarships are of a value varying from £50–£100 per annum.

The William Lindley Bequest Scholar must be the son of a Corporate Member or of an Associate of the Institution, between the age of 16 and 23 years, who is desirous of entering the Civil Engineering profession, but whose means are inadequate to defray the incidental expenses. The scholarship is of the value of £40 per annum.

The detailed regulations may be had on application to the SECRETARY OF THE INSTITUTION OF CIVIL ENGINEERS, Great George Street, Westminster. W 266

Inst. C.E., I. Mech. E., B.Sc., and all Engineering Examinations.

—Mr. G. P. KNOWLES, B.Sc., Assoc. M. Inst. C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Hundreds of successes. Courses may commence at any time.—39, Victoria St., Westminster, S.W. 7670

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Mr. Ewart S. Andrews, B.Sc.

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Marine & Aero-Engines, Alternating Currents, Wireless Course, Ferro-Concrete, Refrigeration, Pract. Maths. and Calculus.—PENNINGTONS, University Tutors, 364, Oxford Rd., Manchester.

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H. E. Holland (late Lecturer

on Mechanical Engineering, School of Military Engineering, also Lecturer, Engineering Group, R.A.C. Higher) OFFERS CORRESPONDENCE TUITION on Theory of Heat Engines, Mechanics, Marine Engine Design, General Engineering Design, &c. Fee, 4s. per two lessons weekly.—Full particulars on application to 166, Rochester Street, Chatham. W 339

TENDERS.

India Office,
Whitehall,
31st May, 1919.

THE SECRETARY OF STATE FOR INDIA, in Council, is prepared to receive

Tenders from such

Persons as may be willing to supply STEEL KEYS FOR SLEEPERS.

The Conditions of Contract may be obtained on application to the DIRECTOR-GENERAL OF STORES, India Office, Whitehall, S.W., and Tenders are to be delivered at that office by Two o'clock p.m. on Tuesday, the 1st July, 1919, after which time no Tender will be received.

G. H. COLLIER, W 319
Director-General of Stores.

ROCKBREAKING.

THE CORK HARBOUR COMMISSIONERS invite

Tenders for the Purchase of a

New Lobnitz ROCKBREAKING GEAR, consisting of a 25 ton Ram to work to 50 ft. under water, with Tripod, Guide Frame, Lifting Winch and Rope.

The Gear can be inspected at the Commissioner's Works at Cork, and the Drawings at the Engineer's Department, Commissioner's Offices, at Cork.

Tenders should be received before One p.m., on Wednesday, June 18th, 1919.

The Commissioners do not bind themselves to accept the highest or any Tender.

By Order,
JAMES LONG,
Secretary.

Cork Harbour Commissioners' Offices,
Custom House Street, Cork.
May 30th, 1919. W 272

SOUTH STAFFORDSHIRE WATERWORKS COMPANY.

BOREHOLES.

The South Staffordshire Waterworks Company invite

Tenders for Two Boreholes,

to be constructed simultaneously at their Maple Brook Pumping Station, Chorley, near Lichfield, Staffordshire.

Copies of Conditions, Specification, Schedule of Prices and Form of Tender, may be obtained, and drawings giving particulars of strata may be inspected, on application to—

FRED J. DIXON, M.Inst.C.E.,
Engineer-in-Chief.

36a, Paradise Street,
Birmingham.
June 2nd, 1919. W 317

G. R.

BY DIRECTION OF THE DISPOSAL BOARD, MINISTRY OF MUNITIONS.

STEEL SURPLUS MATERIAL FOR SALE BY TENDER, FROM H.M.S. "WELLESLEY." Reference D.D. 1/663/Admiralty.

The Minister of Munitions has

FOR DISPOSAL in ONE or MORE LOTS a QUANTITY of ASSORTED MATERIAL in the form of Angles and Bars, as proposed to be used in the building of this ship.

Particulars and Tender Forms may be had on application to D.D. 4A, Room 372, Hotel Métropole, Northumberland Avenue, W.C. 2, quoting the above reference. W 286

G. R.

BY DIRECTION OF THE DISPOSAL BOARD, MINISTRY OF MUNITIONS.

STEEL SURPLUS MATERIAL, FROM H.M.S. "WELLESLEY," FOR SALE BY TENDER. Reference D. D. 1/662/Admiralty.

The Minister of Munitions has

FOR DISPOSAL in ONE or MORE LOTS a QUANTITY of ASSORTED MATERIAL in the form of Steel Plates, Mild Steel Black and Galvanised Sections, Mild Steel Plates and Sheets, Black and Galvanised Sheets, &c., as proposed to be used in the building of this ship.

Particulars and Tender Forms may be had on application to D. D. 4A, Room 372, Hotel Metropole, Northumberland Avenue, W.C. 2, quoting the above reference. W 288

G. R.

BY DIRECTION OF THE DISPOSAL BOARD, MINISTRY OF MUNITIONS.

HOOP IRON AND TINPLATES.

The Minister of Munitions has

FOR DISPOSAL in ONE or MORE LOTS a QUANTITY of MATERIAL in the form of:—

HOOP IRON. Approximately 130 Tons—16s. Gauge, lying at St. Helens.

TINPLATES (D XX). 45 Boxes 25 in. by 17 in.

TINPLATES (D XX). 35 Boxes 28 in. by 20 in., lying at West India Docks.

TINPLATES (D XX). 8½ Tons, lying at Worcester.

Particulars and Tender Forms may be had on application to D.B.4A., Room 372, Hotel Metropole, Northumberland Avenue, W.C. 2, quoting reference B.M./102 and 126/D.B-4A. W 287

DISTRICT ASYLUM, BALLINASLOE.

RENEWAL OF ELECTRIC ACCUMULATORS.

The Joint Committee of Management of above Asylum will, at their Meeting to be held on MONDAY, 9TH day of JUNE, 1919, open and consider

Tenders for the Renewal of

ELECTRIC ACCUMULATOR PLANT, as per specification to be had on application to the Resident Medical Superintendent, from whom any further information may be obtained.

The Accumulator plant consists of 108 cells (15 plates to each cell) and has a normal charge rate of 35 amperes.

Sealed Tenders marked "Accumulators," addressed to the RESIDENT MEDICAL SUPERINTENDENT, to be delivered at this Asylum on or before Twelve o'clock noon, on SATURDAY, the 7TH day of JUNE, 1919.

The lowest or any Tender not necessarily accepted.

By Order of the Committee,
JOHN MILLS,
Resident Medical Superintendent.
13th May, 1919. W 92

JHARIA WATER SUPPLY SCHEME.

Tenders are Invited for the

supply and delivery of WATER PIPES (Cast Iron, Steel or Reinforced Concrete) up to 21 in. internal diameter, together with Sluice Stop Valves, &c., to be used in conjunction with the pipes. If of cast iron, the total weight of pipes will be about 15,000 tons. The total length of pipes of all sizes will be about 102 miles. Sealed tender, accompanied by a deposit of £300 sterling (or equivalent sum, which will be returned to unsuccessful tenderers as soon as possible after the contract is let) will be received at the office of Messrs. SIR ALEXANDER BINNIE, SON & DEACON, 20, Buckingham Gate, Westminster, S.W. 1, up to mid-day on the 31st July, 1919.

Copies of the Form of Tender, Contract Agreement, Specification and Bills of Quantities may be obtained by sending in an application with a deposit of £6 sterling (or equivalent sum) for each copy applied for to Messrs. SIR ALEXANDER BINNIE, SON & DEACON, 20, Buckingham Gate, Westminster, S.W. 1, and such deposit will be refunded when a *bona fide* tender accompanied by the Specification, &c., has been received by the Chairman of the Jharia Water Board. The Board does not bind itself to accept the lowest or any tender.

(Signed) T. LUEY,
Chairman of the Jharia Water Board,
Dhanbad, E.I.R. W 226

FAVERSHAM RURAL DISTRICT COUNCIL, COUNTY OF KENT.

PARISHES OF BOUGHTON AND DUNKIRK.

TO MANUFACTURERS OF OIL ENGINES AND PUMPS, &c.

The Faversham Rural District Council is prepared to receive

Tenders for the Supply and

DELIVERY, &c., of a 25 B.HP. OIL ENGINE and TWO SETS of PUMPS, &c., for Water Works at BOUGHTON, near Faversham, in the County of Kent.

Specification and Particulars may be obtained from the Council's Consulting Engineer, Mr. H. Howard Humphreys, of 26, Victoria Street, Westminster, on and after 16th JUNE, 1919, between the hours of Ten a.m. and Four p.m.

Intending Contractors will be required to deposit the sum of Three Guineas, prior to particulars being furnished, such sum being returned on receipt of a bona-fide Tender.

Tenders endorsed "Boughton Machinery," must reach the undersigned, not later than Four p.m., on Monday, the 30th June, 1919.

The Council does not bind itself to accept the lowest or any Tender.

Given under my hand this 3rd day of June, 1919.

GUY TASSELL,
Clerk to the Council.

19, West Street,
Faversham, Kent. W 300

METROPOLITAN WATER BOARD.

TENDERS FOR THE SUPPLY OF STORES AND EXECUTION OF WORK, &c.

The Metropolitan Water Board are prepared to receive

Tenders for the Supply of

the undermentioned STORES, and the EXECUTION OF WORK, &c., for the periods of Three or Six Months, or the period commencing 1st August, 1919, to 31st March, 1920, as the Board may decide.

Tender No.

1.—Bricks, Firebricks, Slates, Cement.
2.—Brushes and Brooms.
3.—Cast-Iron Pipes and Irregular Castings.
5.—Cotton Waste, Engine Wipers.
6.—Hemp, Rope.
8.—Iron and Steel.
9.—Ironmongery and Tools.
10.—Lead, Brass, Copper, Zinc, and Glass.
11.—Meter Repairs.
12.—Oils (Lubricating).
13.—Oilman's Sundries.
14.—Packings, Rubber Goods.
15.—Paints, Colours and Varnish.
16.—Scrap Iron, Purchase and Removal of.
19.—Small Iron Castings.
20.—Screwdown Stop Ferrules and Stop Valves.
21.—Sluice Valves.
22.—Timber.
23.—Weighing Apparatus.
25.—Electric Lamps, Electric Wire and Accessories.

Tenders must be made on official Forms, which may be obtained from the CHIEF ENGINEER, 2, South Place, Finsbury, E.C. 2, on or after Wednesday, the 11th June, 1919, by personal application, or on receipt of a stamped addressed brief envelope.

Applicants should refer to the number of the Tender for which Forms are required.

Tenders, must be sent under sealed cover, addressed to the CLERK OF THE BOARD, Metropolitan Water Board, South Place, Finsbury, E.C. 2, endorsed "Tender for ....," and must be delivered at the Offices of the Board, not later than 11 a.m. on Wednesday, 25th June, 1919.

The Board do not bind themselves to accept the lowest or any Tender.

A. B. PILLING,
Clerk of the Board.
2, South Place,
Finsbury Pavement, E.C. 2.
28th May, 1919. W 285

APPOINTMENTS OPEN.

UNIVERSITY OF HONGKONG.

The Following Appointments

will shortly be made:—

(1) Professor of Physics. Salary £500.
(2) and (3) Lecturers in Civil and Mechanical Engineering (Two). Salary £400.
(4) Lecturer in Electrical Engineering. Salary £400.

Quarters (or an allowance) provided in each case.

Applications should be made out in duplicate and addressed to A. A. A., care of J. W. VICKERS & Co., LTD., 5, Nicholas Lane, E.C. 4. Successful Candidates must be in Hongkong not later than 1st September, 1919. W 334

STAFFORDSHIRE EDUCATION COMMITTEE. BRIERLEY HILL HIGHER EDUCATION COMMITTEE.

Applications are Invited for

the POST of HEAD MASTER of the Technical School, Brierley Hill, South Staffordshire. Experience in teaching and acquaintance with the Iron and Steel Trades, or with the Chemistry of Refractory Materials desirable.

Initial salary, £300 a year.

Further particulars and forms of application may be obtained from the undersigned. Applications must be received not later than 30th June, 1919.

GRAHAM BALFOUR,
Director of Education.
County Education Offices, Stafford.
June, 1919. W 290

RADCLIFFE EDUCATION COMMITTEE. TECHNICAL SCHOOL.

Wanted, a Graduate Assistant

MASTER, for combined duties in the Junior Day Technical School and Evening Technical Classes, to commence duties in September next.

Principal Subjects:—Physics, Engineering Drawing, Handicraft (Metal Work).

Commencing salary according to previous experience, but not exceeding £255 per annum, increments according to Lancashire County scale, to a maximum of £450.

Applications, endorsed "Technical Assistant Master," stating age, industrial and teaching experience, and accompanied by not more than three recent testimonials, must be in my hands not later than 30th June, 1919.

S. MILLS,
Secretary for Education.
Council Offices, Radcliffe.
June 4th, 1919. W 304

UNIVERSITY OF MANITOBA.

APPOINTMENT IN CIVIL ENGINEERING.

The Board of Governors will proceed shortly to

Appoint a Professor of Civil

Engineering to take charge of the Department. Initial salary, $3600. Applications, accompanied by full statement of training and experience, and ten copies of testimonials, will be received up to July 15th, 1919, by

THE SECRETARY,
Board of Governors,
University of Manitoba, W 159
Winnipeg, Canada.

UNIVERSITY COLLEGE, NOTTINGHAM.

DEPARTMENT OF ENGINEERING.

LECTURER IN MECHANICAL ENGINEERING.

Applications are Invited for

the POST of LECTURER in Mechanical Engineering, at a commencing salary of £250 per annum.

Particulars and forms of application, which should be returned not later than June 18th, may be obtained from

J. E. SHIMELD, W 186
Acting Registrar.

GLAMORGAN EDUCATION COMMITTEE.

APPOINTMENT OF LECTURERS IN MECHANICAL ENGINEERING.

The Committee propose to

Appoint Two Additional

LECTURERS in Mechanical Engineering. Applicants must possess special qualifications for teaching Mechanical Engineering and allied subjects. Successful candidates must devote their whole time to the duties and reside where directed by the Committee.

Salaries £350 per annum, rising by annual increments of £10 to a maximum of £380, with expenses according to scale. Regard will be had to previous experience in assessing the commencing salary. Canvassing will disqualify.

Applications, on forms which will be supplied on receipt of a stamped addressed foolscap envelope, accompanied by copies of not more than three recent testimonials, must reach the CHIEF EDUCATION OFFICIAL, County Hall, Cardiff, by 14th June, 1919. W 145

UNIVERSITY OF LONDON GOLDSMITHS' COLLEGE, NEW CROSS, S.E. 14.

ENGINEERING AND BUILDING DEPARTMENT.

Applications are Invited for

the POST of LECTURER in Practical Mathematics. Commencing salary £150 to £240 per annum according to experience and qualifications, rising by £15 increments to £300 and then by £10 increments to £400. A War bonus of £39 per annum is at present paid in addition.

Candidates must have had some experience in teaching and should preferably have had some Engineering experience. They should also possess a University degree or its equivalent.

Applications to be sent on or before June 24th to the ACTING WARDEN, from whom further particulars may be obtained. W 311

UNIVERSITY COLLEGE OF SOUTH WALES AND MONMOUTHSHIRE.

(COLEG PRIFATHROFAOL DEHEUDIR CYMRU A MYNWY.)

The Council of the College invites

Applications for the following

POSTS. Applications, with testimonials (which need not be printed), must be received by the undersigned on or before the date stated in brackets after the title of each post.

(1) Assistant Lecturer and Demonstrator in Engineering. (June 14, 1919.)
(2) Assistant Lecturer and Demonstrator in Metallurgy. (June 30, 1919.)

Further particulars regarding the above posts may be obtained from the undersigned.

D. J. A. BROWN,
Registrar.

University College,
Cardiff.
May 17th, 1919. U 984

ASSISTANT TRAFFIC SUPERINTENDENTS, INDIAN STATE RAILWAYS.

THE SECRETARY OF STATE FOR INDIA IN COUNCIL will, in 1919, make

Six Appointments as

ASSISTANT SUPERINTENDENTS in the Traffic Department of Indian State Railways, if so many suitable Candidates offer themselves. The Appointments will be reserved for Candidates who have served in His Majesty's Forces during the War for at least one year, or who have been prevented on adequate grounds from so serving.

Every Candidate must be a British subject, of not more than 29 years of age on 1st August, 1919, and of good moral character and sound physique.

Candidates must possess one or other of the following qualifications:—

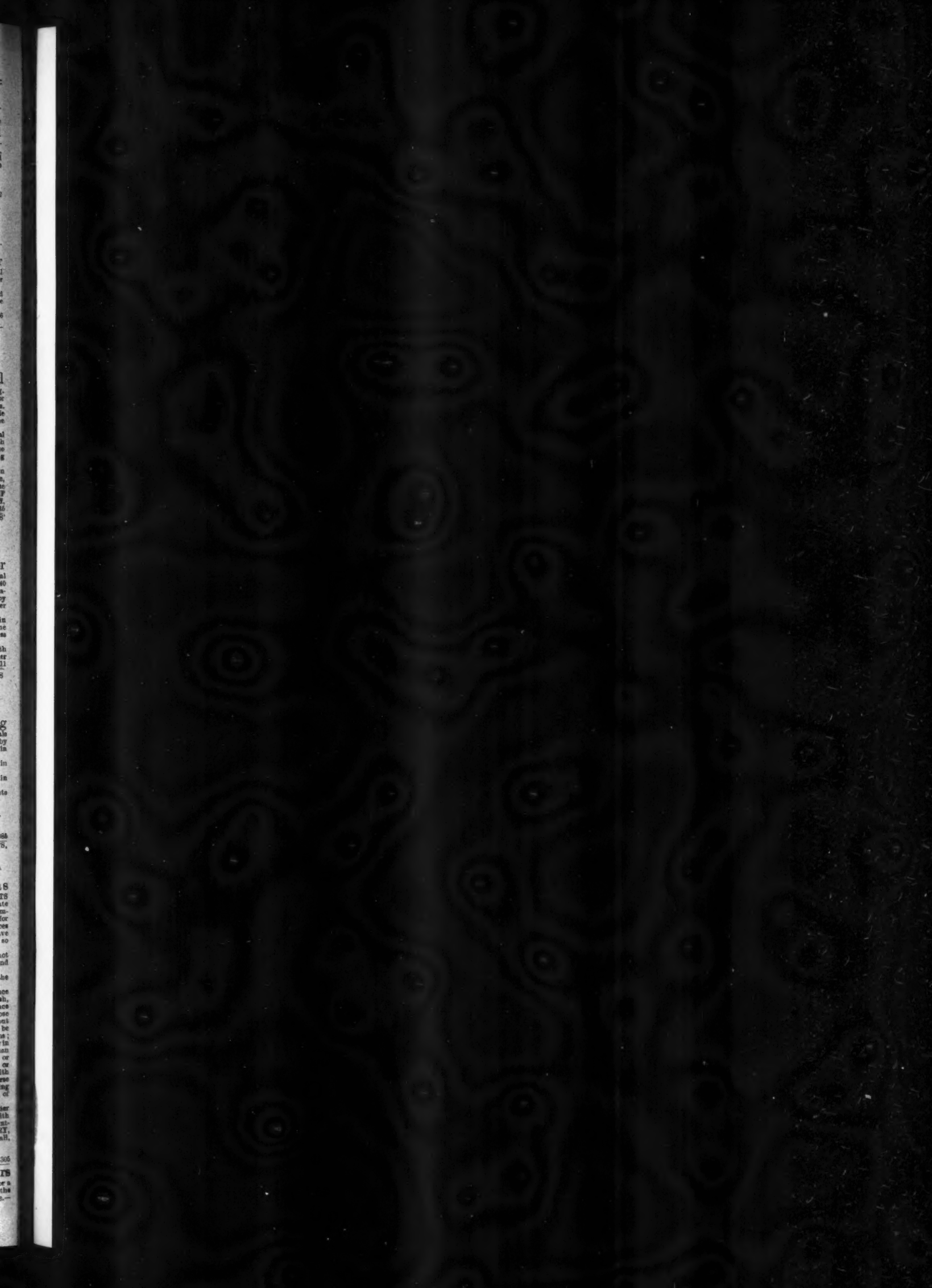
(1) Not less than two years' practical experience of work in the Traffic Department of a British, Colonial or Military railway, together with evidence of a sound general education. Persons whose practical experience falls short of two years, but who have served in His Majesty's Forces, will be eligible as Candidates, subject to certain conditions; (2) a degree or diploma of any teaching University in the United Kingdom granted after not less than three years' study, or a technical diploma or certificate recognized by the Secretary of State; or (3) must produce evidence of having entered with reasonable prospect of success, upon the course leading to such degree or diploma, and of having been prevented from continuing it by the fact of joining His Majesty's Forces.

Applications must reach the India Office not later than 30th June, 1919. Printed forms, together with information regarding the conditions of appointment, may be obtained from the SECRETARY, Public Works Department, India Office, Whitehall, S.W. 1.

India Office, Whitehall,
1st March, 1919. W 305

A Large Firm of Engineers

in the Midlands, have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4250, Offices of ENGINEERING.



THE ATTACK OF POTS FOR GLASS MELTING.

FROM our annual reports on the work of the National Physical Laboratory our readers are aware that researches on the manufacture of optical glass have for some years past, been in progress at that Institution. These researches have been conducted under the direction of Dr. W. Rosenhain, F.R.S., by Mr. E. A. Coad-Pryor, B.A., Mr. V. H. Stott, M.Sc., and Miss A. B. Taylor, with the aid of a grant from the Board of Trade in 1915 and, later, of the Department of Scientific and Industrial Research. Particulars of the investigations were withheld during the war years; but discoursing, on May 21, before the Society of Glass Technologists, on "Some Phenomena of Pot-Attack," Dr. Rosenhain was able to give an interesting account of one line of these inquiries, namely the search for an ideal pot which, owing either to its special material or to some special treatment, would resist pot attack

Fig. 1.

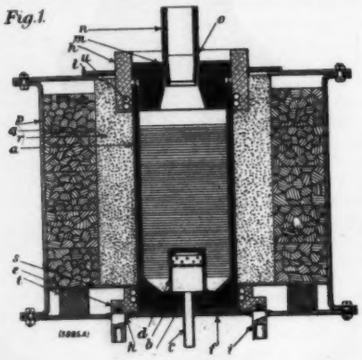


Fig. 2.

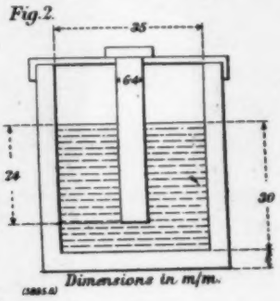


Fig. 3.

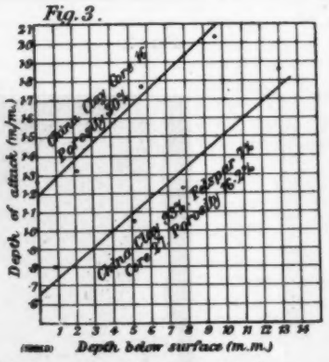
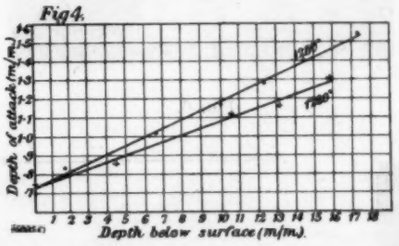


Fig. 4.



even by the most active types of glasses such as those containing high percentages of lead or barium together with boric acid.

For this purpose a systematic study of the exact nature of the attack of molten glass on the pot or its lining was required, and though the study of pot-attack is by no means novel, as Dr. Rosenhain pointed out, the problem does not appear to have systematically been investigated. Glass manufacturers have all met with examples of prematurely "drilled" pots. The inquiries into such cases are generally somewhat of the nature of a "post-mortem" examination, with the added disadvantage that very possibly the cause of death has disappeared long before the examination has been made. The only satisfactory method of study, on which Dr. Rosenhain decided, seemed to be to watch the attack under controlled and standardised conditions of temperature, time, atmosphere and glass composition, and to interrupt the operations and to examine the broken or cut up pot in various ways. Such a programme could not well be carried out under manufacturing conditions, nor on any large scale, on account of the great expense involved. The experiments were hence started on the smallest suitable scale, leaving the translation to a large scale and the application to works practice for a later stage.

In order to secure adequate control of temperature and furnace conditions the pots under test were heated in an electric furnace (Fig. 1), also developed in the Metallurgical Department of the National Physical Laboratory. It is a resistance furnace, the vertical tube of which is built up of conical rings of graphite stacked on the top of one another in any number desirable. Temperatures lying mostly between 1,230 deg. and 1,280 deg. C., controlled by thermocouples, could easily be maintained in these furnaces. To keep off reducing gases liberated from the hot graphite a liner of silicon carbide is introduced between the pot and the graphite tube, and the inner space is charged with nitrogen; high-lead glasses could then be melted without undergoing any reduction, but the precaution was hardly necessary, since experiments with gas fires and air blasts gave practically the same results. As regards pot material, a preliminary inquiry showed that fireclay is unsuitable for standard conditions—the method of examination by X-rays will be referred to later—and the purest china clay was adopted, the material containing 92·25 per cent. of clay substance, 3·57 per cent. of feldspar and 4·18 per cent. of quartz. Pots were made of this material by a slip-casting process in open plaster moulds, the slip consisting of 60 per cent. of the clay and 40 per cent. of "grog" with the usual additions of deflocculators; the grog was obtained by firing balls of the same china clay in a special kiln to a temperature above 18 cone and subsequently grinding and sieving the material through a 60-mesh screen. The pots (Fig. 2) are quite small, 35 mm. diameter, and filled up to a height of 30 mm. The lid is made of the same material as the pot, and so is the axial rod, which passes through a central hole in the lid. This rod has proved very convenient for studying the erosion of the pot material by the molten glass.

The first choice of glass was influenced by the chief aim of the general research, the study of optical glass. These glasses, rich in baryta and boric acid, are moreover known to be very fluid at moderate temperatures and hence to put the pots to severe tests. The first glass chosen, numbered S.G. 4, contained 3·8 per cent. of Na_2O, 56·7 per cent. BaO, 17·3 per cent. B_2O_3 and 22·2 per cent. SiO_2; the glass S.G. 6 contained 3·6 per cent. Na_2O, 39·5 per cent. BaO, 12 per cent. B_2O_3, 36·1 per cent. SiO_2 and 8·8 per cent. Al_2O_3; the S.G. 5 was a flint, 11·8 per cent. Na_2O, 42·5 per cent. PbO, 45·7 per cent. SiO_2; various other flints were used, as well as ordinary soda-lime glass and other glasses. The results were found to be so uniform that general conclusions appear justified.

The object of the experiments being the study of the action on the clay by the molten glass, and not the action of various raw materials, the glass experimented with was in each case first fused in china-clay pots—larger than those described—and granulated by pouring the fused glass into water; the pot under test was filled with this "water-cullet," the charge being sufficient to take up when fused about two-thirds of the pot. The filled pot was placed on pure sand within a larger pot, which itself was put on the lower electrode of the furnace (Fig. 1). In cases when the molten charge pierced the inner pot, the sand absorbed the escaping glass, and the outer pot protected the furnace. The pot was slowly heated up to 700 deg., which took an hour, and then quickly, in 10 minutes, to 1,260 deg. or 1,280 deg.; the whole heating lasted 2 hours or longer, and the time of exposure was recorded. Below 700 deg. there was no chemical attack, and with the rates of heating adopted cracking of the pots was not to be feared.

The quantitative study called for measurements of the pot and its rod before and after heating. Four spots were marked, with specks of cobalt, on the outside of the pot bottom, and the thickness of the bottom at these spots was measured; the rod diameters could be directly determined at various points. The measurements after the attack were a more difficult matter, since the glass adhered to the clay, and the surface attack was irregular. Sections were made through the marks and through the rods, and photographs were taken of the sections or drawings prepared with the aid of a *camera lucida* (magnification 10 diameters). Planimeter measurements were then taken of the photographs or drawings to ascertain the depth of the attack, *i.e.*, the difference between the original and the final thickness or diameter. From the measurements the curves of Figs. 3 and 4 are deduced.

As regards the pot the main attack, as was expected, is on the bottom and the lower parts of the sides, the bottom being sometimes pitted in a series of incipient drills lying roughly on a circle near the side, as shown in Fig. 8, on page 726; in other cases the attack was more general. The rods were worn down in a V taper (Fig. 5), and this increase of the depth of the attack with increasing depth of immersion was unexpected, but confirmed by larger scale experiments with charges of 15 kg. of glass and stirring rods dipping 20 cm. into the molten glass, and by careful measurements on a very large number of rods in various glasses. In the diagrams Figs. 3 and 4 the depth of attack is plotted as ordinate against the depth of immersion. The upper curve in Fig. 3 refers to a rod (in S.G. 4 glass) containing 30 per cent. (instead of the usual 40 per cent.) of grog; the rod had been fired at cone 16, and its porosity was 30 per cent. The rod of the lower curve contained 7 per cent. of feldspar and had been fired at cone 27; the material was more of the nature of a hard porcelain than of a fireclay, and the real porosity was only 16 per cent. Both the graphs indicate a straight-line law of erosion and have practically the same slope of about 45 deg. Another curve obtained (not reproduced) would fall between the two graphs of Fig. 3; the glass in that case was again S.G. 4; the rod contained 40 per cent. of grog, had been fired at cone 17, and the porosity was 28·5 per cent.; in spite of this high porosity the erosion was moderate, and porosity might not play so important a part in the phenomena, Dr. Rosenhain suggested, as had been supposed.

The rod of Fig. 4 was tried in the glass S.G. 6; the glass was heated to higher temperatures than the other more fusible glasses, and the heating was continued for 5 hours. Of the two graphs the upper shows the erosion at 1,280 deg. C., the lower at 1,260 deg. The attack, it will be seen, was less severe than in the previous cases, but decidedly more severe at the higher temperature than at the lower temperature, though the difference amounted to 20 deg. C. only.

Whether or not the approximation to a straight line law, *i.e.*, increasing rod attack with increasing depth of immersion, would hold for large pots and deep immersion, Dr. Rosenhain was not prepared to say. But it did hold within a certain range, and constituted a new, so far apparently overlooked fact, which had to be accounted for. The V-taper could not be due to the increased hydrostatic pressure with increasing depth of immersion; for slight increases in pressure, it is well known, have little influence on solubility. There is, moreover, a surface effect, the formation of a groove at the fluid level in the pot and of a neck in the rod. Gas action seemed to be out

of the question, and it occurred to Mr. Coad-Pryor to investigate the general problem of the dissolution of solid rods in liquids and the circulation set up in such processes. Cylindrical rods of various salts were prepared in moulds and lowered into water; plaster of Paris was similarly dealt with in dilute hydrochloric acid. The latter experiment was demonstrated with a rod dipping into a glass cell. Within a few minutes a shoulder and a small neck were formed, and the cylinder wore down, not to a V, but to an inverted A—or A—as Dr. Rosenhain called it in distinction. It could be seen that the liquid streamed down the cylindrical walls and flowed down from the bottom of the cylinder to the bottom in water (Fig. 6) and the V taper of naphthalene in carbon tetrachloride (Fig. 7). The demonstrations also showed very distinctly the violent surface agitation of the liquid which is responsible for the formation of the neck in the case of naphthalene.

The phenomena in the glass melting-pot are hence clearly of the type where the solvents, glasses of density 3·75 (S. G. 4) of 3·2 (S. G. 6), are heavier than the solute, the china clay of the rod, density 2·6. The glasses just mentioned give the V taper and a shoulder, without neck, the flints give also a neck. Further to prove the analogy, experiments were made with clay rods in glasses very high in boric acid and lighter hence than hot, and a compensating downward flow will be set up near the walls; that downward current would explain the drilling of the bottom in a circle as illustrated in Fig. 8. When a small pit is produced somewhere in the pot, owing to some local defect, for instance, that pit would act like a small pot and tend to deepen. Dr. Rosenhain could refer to several experimental observations supporting the assumed general circulation. In cases where the rod tapered to an A, not to a V, the general circulation would be different, and there were then no signs of bottom drilling; serious drilling of the walls was, however, observed in a ring below the glass level. When the bottom was protected

FIG. 5.

FIG. 6.

FIG. 7.

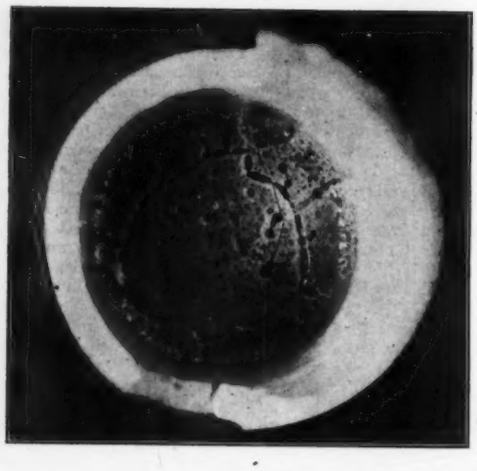


FIG. 8.

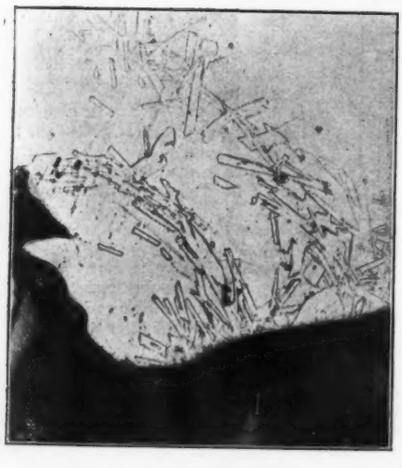


FIG. 9.

FIG. 10.

of the cell, to rise again further away from the rod. As the water or acid in contact with the cylinder became denser and saturated with the salt, it descended, and lost its solvent activity, being replaced by fresh water from the surface. Thus the A taper is accounted for in the case of solvents and solutes (water and salt), the solutions of which are heavier than the solvent. If the solution were lighter than the solvent, the circulation should be reversed, and the A taper should change into a V taper. This condition Mr. Coad-Pryor exemplified by dissolving rods of paraffin or naphthalene in carbontetrachloride (density 1·63), and that case was also demonstrated. The solution, being lighter than the solvent, was seen to rise along the rod which assumed the V taper; the paraffin rod further developed a shoulder, without a neck, the naphthalene rod a neck. Our illustrations show the A taper for cylinders of barium chloride the rod material; A tapers were observed. Owing partly to capillary attraction—possibly also to optical effects—the neck groove seemed to set in above the liquid level, not in it. Surface tension and the changes it undergoes when solids are dissolved in a liquid no doubt are important factors in the phenomena. We know that pieces of camphor and crystal of certain dyes, etc., placed on water, dart about in an odd fashion; solutions in alcohol and in water are violently agitated when poured on one another, and C. R. Darling produced nearly ten years ago, some peculiarly beautiful effects by dropping othhotoluidin on water. But we know very little about the surface tension of molten glass, though the tension certainly exerts a powerful influence on glass during industrial operations. Whatever the nature of surface tension in the melting glass, however, there will be an upward flow of glass along the walls of the pot as it grows by placing a disc of zirconia (96 per cent.) on it, the bottom remained intact, but the deflected circulation attacked the lower part of the wall. There is thus danger in such local Protective devices. With the aid of suitable deflectors, guard-rings, near the surface, *e.g.*, Dr. Rosenhain yet hopes to suppress the circulation and to diminish pot-attack. The guard-devices might be made of materials, appropriate to balance, or "loaded," to reverse the circulation-currents.

As regards the study of the general properties of molten glass the investigation of the viscosity tends to show that increased viscosity reduces the speed of the currents without appreciably affecting the type of circulation. Viscosity enters into the phenomena in another way as well, however. The boundary between pot and glass does not remain sharp; while solution is going on, there must be a minute zone in which the change in viscosity is rapid. If there were no agitation, the gradient would be steep and, diffusion being slow, further solution would soon be stopped. As

the determination of the viscosity of glass and of its temperature coefficient is very difficult, they have at the National Physical Laboratory arrested the process by cooling down the pot with its charge, and have examined sections of the boundary region between the pot and the adherent glass by the microscope after etching them with hydrofluoric acid. The crystals formed are difficult to photograph; the photomicrographs show needle crystals, observed with the S.G. 6 glass (Fig. 9), and peculiar massive crystals found near the pot wall in the flint S.G. 5 (Fig. 10).

The last slides of Dr. Rosenhain, illustrating the good services which the X-rays can render to the glass-makers, did not excite less interest than the study of the pot-attack. In a radiograph (not reproduced) taken right through the experimental pot as standing before being fired, the bottom appeared as a grey disc surrounded by a dark rim (the cylindrical wall), and black spots could be seen in the bottom; these spots marked specks of iron oxide. In another radiograph, taken after firing the pot, the specks had the appearance of somewhat larger dark rings, light grey in the centre; the iron oxide had evidently fused the clay immediately next to it, leaving a small central cavity. Irregular whitish spots, due to bits of plaster (from the mould) embedded in the clay, were easily distinguished from the annular iron spots; and the presence of air bubbles again could easily be recognised in the pots. The examination by X-rays both of the green pots and the fired pots is a simple matter, that the timely disclosure of local defects would fully repay. The direct problem, the investigation of pot attack, will, of course, as Dr. Rosenhain pointed out in conclusion, demand much further study. The ideal pot material has not yet been found. But the results obtained lend themselves to useful interpretation. Take the diagram, Fig. 4. The pot-attack is much more serious at 1,280 deg. than at 1,260 deg. If such a state be observed, the glass-maker may be able either to keep within the safe temperature range, or to modify the composition of his glass. In some cases, at any rate, a relatively simple experimental examination on the lines indicated would enable the glass-maker to avoid expensive pot- and glass-failures.

THE EFFECT OF A SIDE-WIND ON INTERPLANE STRUTS.

By A. J. SUTTON PIPPARD, M.Sc., A.M.I.C.E.

As long as an aeroplane is flying directly into the wind the loads in the interplane struts are purely compressive. If, however, the wind strikes at an angle to the longitudinal axis of the struts they are subjected to a lateral force in addition. Such a side force is usually caused by a side-slipping on the part of the aeroplane and should be taken into account when designing interplane struts.

The magnitude of this force cannot be accurately determined, but the methods given in this article will enable a correction to be applied to take sufficient account of the side wind.

Suppose an aeroplane to be flying at a forward velocity = V ft.-sec.

Let the side-slip velocity = v ft.-sec.

Then the direction of the wind on the struts is at an angle a to their axes, such that:

$$\text{Tan } a = v/V.$$

Also, the velocity of the aeroplane along the resultant direction of V and v is given by V Sec a.

The strut acts in a similar manner to an aerofoil section, the lift being the side force or cross-wind force whose magnitude is required.

Let the length of a strut = L inches.
Let the width of a strut = t inches.
Let the fore and aft length of the strut = γt inches.

Then the area of the side surface of the strut = $L \gamma t$ sq. in. The side-wind force on the strut will be:

$$F = k_L \cdot \rho \cdot \frac{L \cdot \gamma t}{144} \cdot V^2 \text{ Sec}^2 a \quad . \quad . \quad (1)$$

where ρ is the density of the air.
and k_L is a "lift-coefficient."

From an examination of a series of tests on strut sections it was found that for a good value of γ the value of k_L reached as much as 0·033 per degree; the angle at which streamline flow broke down being 16 deg.

A side-slip velocity which makes a = 16 deg. may therefore be taken as the worst case likely to occur.

In this case k_L = 0·033 × 16 = 0·528.
Also, sec a = 1·0403 and ρ = 0·00237.

Let w be the lateral force per inch run of the strut. Then from equation (1):

$$w = k_L \cdot \rho \cdot \frac{\gamma t}{144} \cdot V^2 \text{ Sec}^2 a.$$

Substituting for k_L, sec a and ρ:

$$w = \frac{0{\cdot}528 \times 0.00237 \times (1{\cdot}0403)^2}{144} \cdot \gamma \cdot t \cdot V^2$$

i.e., $w = 0{\cdot}00000943\ \gamma \cdot t \cdot V^2$ . . . . . (2)

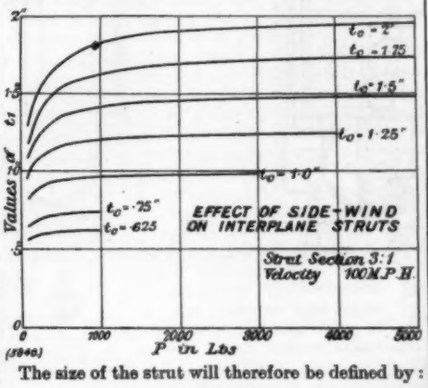
Let the maximum direct compressive load which a strut has to carry, including the factor, be P.

Let the thickness of the strut which will just carry this load, making no allowance for lateral load, = t_1.

Then the length of the section as before = γt_1

The minimum moment of inertia of the strut = βt_1^4.

Since an interplane strut is of sufficient length to fail by buckling, the strength to resist an end load only can be found from Euler's formula.



The size of the strut will therefore be defined by:

$$P = \frac{\pi^2 E \beta t_1^4}{L^2} \cdot \quad . \quad . \quad . \quad . \quad (3)$$

E being the modulus of elasticity of the material. For a laterally loaded strut the maximum bending moment is given by:

$$M_0 = \frac{w E I}{P} \left\{ \text{Sec} \frac{\pi}{2} \sqrt{\frac{P}{Q}} - 1 \right\}$$

where Q is the Euler failing load of the member.

Since the direct-compressive stress is a very small factor in an interplane strut, the maximum stress in such a member when subjected to a lateral load is:

$$f = \frac{w E t_0}{2 P} \left\{ \text{Sec} \frac{\pi}{2} \sqrt{\frac{P L^2}{\pi^2 E \beta t_0^4}} - 1 \right\} \quad . \quad (4)$$

where t_0 is the thickness of a strut to carry an end load P lb., and a side load w lb. per inch.

But

$$\frac{P L^2}{\pi^2 E \beta} = t_1^4 \quad \text{from eq. (3)}$$

So that, substituting in (4):

$$f = \frac{w \cdot E \cdot t_0}{2 P} \left\{ \text{Sec} \frac{\pi}{2} \left(\frac{t_1^2}{t_0^2} \right) - 1 \right\}$$

And, substituting for w from (2):

$$f = \frac{0{\cdot}00000943\ \gamma t_0^2 V^2 E}{2 P} \left\{ \text{Sec} \frac{\pi}{2} \left(\frac{t_1}{t_0} \right)^2 - 1 \right\}$$

Since the value taken for P includes the factor, the value of f must be the ultimate stress.

For best quality silver spruce:

f = 5,500 lbs. per square inch in combined end load and bending.
E = 1·6 × 10^6 lbs. per square inch.

so that:

$$5{,}500 = \frac{0{\cdot}00000943 \times 1{\cdot}6 \times 10^6}{2} V^2 \left(\frac{\gamma t_0^2}{P} \right) \left\{ \text{Sec} \frac{\pi}{2} \left(\frac{t_1}{t_0} \right)^2 - 1 \right\}$$

or

$$\text{Sec} \frac{\pi}{2} \left(\frac{t_1}{t_0} \right)^2 = 728 \frac{P}{\gamma t_0^2 V^2} + 1 \quad . \quad (5)$$

From this equation the relation between t_1 and t_0 can be found if the values of P and V are known. P, of course, is always fixed, and V should be taken as the top speed of the aeroplane, since no factor has been allowed upon the lateral loading. The best way of expressing the result of this equation is in a series of curves obtained, as follows.

A standard streamline section, having been selected, γ is fixed. Now decide on a value of V—this will embrace all aeroplanes of a particular class. V and γ thus settled, take a series of values of t_0, and for each of this series calculate t_1 for a range of values of P. By this means a family of curves can be plotted which readily give the correction required to allow for a lateral load. Such a series of curves is plotted in the annexed diagram, for a 3:1 streamline section, and a value of V of 147 ft. per second. The equation (5) reduces to:

$$\text{Sec} \frac{\pi}{2} \left(\frac{t_1}{t_0} \right)^2 = \frac{\cdot 0112\ P}{t_0^2} + 1 \quad . \quad . \quad (6)$$

To use such a curve, first design the strut, making no allowance for windage and so find t_1.

Find the point on the chart where this value of t_1 intersects the line through the value of P which the strut has to carry. By interpolation between the curves of t_0, the corrected thickness of the strut is found.

As an example, design a strut 80 in. long to carry a load of 1,200 lb.

The moment of inertia may be taken as 0·12 t_1^4:

$$\therefore t_1^4 = \frac{1{,}200 \times 80^2}{\pi^2 \times 1{\cdot}6 \times 10^6 \times 0{\cdot}12}$$

or

$$t_1 = 1{\cdot}42".$$

The intersection of the lines t_1 = 1·42, and P = 1,200, occurs practically on the curve t_0=1·5 in., so instead of the strut being 1·42 in. wide it should be 1·5 in.

Curves for different values of γ and V can very quickly be obtained and once these have been plotted they form standard graphs.

OERLIKON LOCOMOTIVES FOR THE SWISS FEDERAL RAILWAYS.

IN an article in our issue of May 2 last, Mr. J. Buchli described some electric locomotives built by Messrs. Brown Boveri and Co. and the Swiss Locomotive and Machine Company for the Swiss Federal Railways, and for operating on the Bernese Alpine Railway. As stated in the early part of that article, the authorities of the Swiss Federal Railways decided to have four trial locomotives built and tested before larger numbers were put in hand. Two locomotives of the four were supplied by Messrs. Brown Boveri, and were described in the article to which we have referred. The remaining two were supplied by the Ateliers de Construction Oerlikon of Oerlikon, Switzerland, and it is the purpose of this article to give some description of these latter. As in the case of the Brown Boveri products, the mechanical parts of the locomotives was supplied by the Swiss Locomotive and Machine Company, of Winterthur. The Oerlikon locomotives have been delivered and have carried out their trials on the Loetschberg Railway.

The two locomotives supplied comprised one each of two different types, of which the chief dimensions are given in the following table:—

	2-6-2	2-4-4-2
Locomotive type		
System	Single-phase	Single-phase
Voltage	15,000	15,000
Periodicity, per second ...	16⅔	16⅔
Horse-power at wheel rims	1,650	2,250
Draw-bar pull (1¼ hour test), lb.	19,000	26,000
Maximum draw-bar pull, lb.	30,000	40,000
Normal speed ... m.p.h.	31	31
Maximum speed ... m.p.h.	47	47
Weight of mechanical parts, tons	46.5	58.5
Weight of electrical parts, tons	44.5	54.5
Total weight, tons... ...	91	113
Adherent weight, tons ...	58.5	80

Both classes of locomotive have a two-wheeled Bissell truck at the leading and railing ends, but in one type three pairs of coupled driving wheels are placed at the centre, while the other has two sets of two pairs of coupled wheels. One of the locomotives—the 2-6-2 type—is illustrated in Figs. 1 and 2, on Plate LV, while cross-sections of the same locomotive are given in Figs. 3 to 5, on page 728. General views of the two locomotives

15,000-VOLT SINGLE-PHASE ELECTRIC LOCOMOTIVE.

CONSTRUCTED BY LES ATELIERS DE CONSTRUCTION OERLIKON, ENGINEERS, OERLIKON, SWITZERLAND.

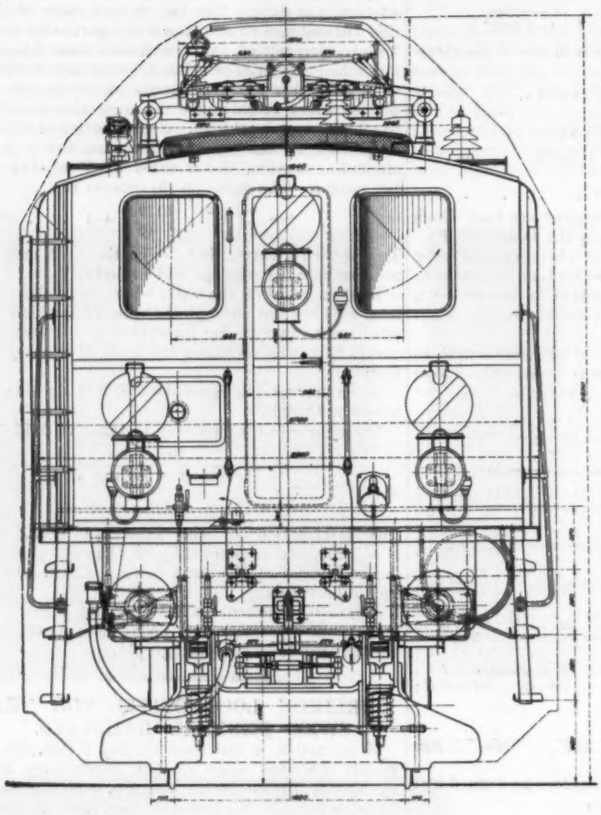


FIG. 3.

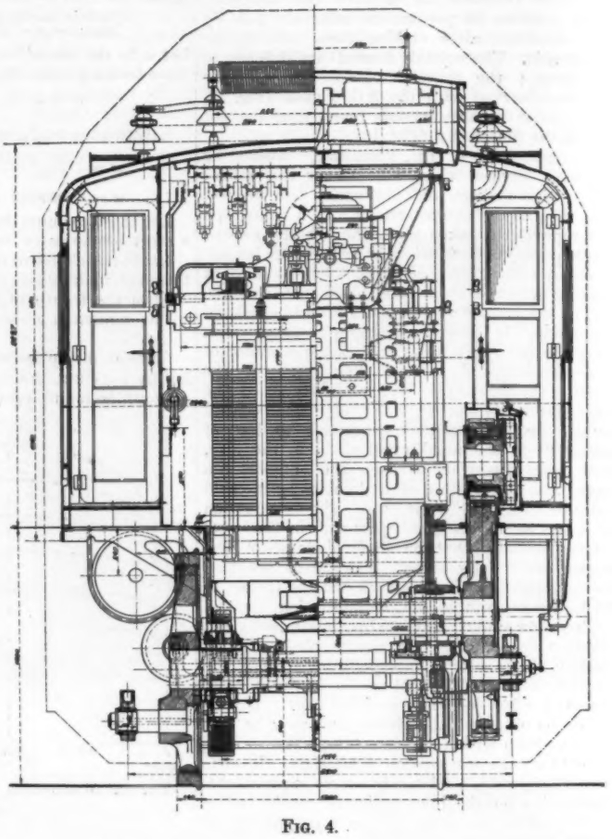


FIG. 4.

are shown in Figs. 6 and 7, on page 740. It is unnecessary to describe both locomotives in detail, as in many features they are similar. We will accordingly deal in the main with the 2-6-2 type illustrated in Figs. 1 to 5, and will afterwards refer briefly to any special features possessed by the other. The general arrangement is well shown in Fig. 1. The leading and trailing trucks are of the Bissell type and have a lateral play of 3 in. They are returned to their middle position by two plate springs. To ease the travelling of the locomotive, when running round curves, the driving wheels are also capable of a lateral play of 1 in. on each side. The locomotive is driven by two motors situated side by side and above the level of the cab floor, as is best shown in Fig. 6. Each motor shaft carries a pinion at each end, so that there are four pinions in all. The pinions gear with spur wheels carrying on their faces crank-pins which are coupled by the triangular-shaped frame shown. This operates the centre driving wheel through a reciprocating cross-head block, while the outer wheels are connected to it by means of coupling rods. The arrangement will be quite clear from the various figures. The pinions are connected to their shafts through flexible couplings giving elasticity of drive.

The main frame of each locomotive is built up of two longitudinal members made from 1-in. plate. The suspension is such that each carrying axle is connected by compensating bars to the adjacent motor axle. Further, the spur wheels, with their shafts, can be removed without dismantling the main suspension in any way. The cab is divided into five compartments, a driving cabin being situated at each end, inside of each of which there is a transformer compartment with a motor section in the middle. The side panels are removable for the inspection or repair of the motors and transformers. A ladder giving access to the top of the locomotive is locked with a whistle connected to the compressed air supply, which gives warning if an attempt is made to mount the roof with the pantograph collectors raised. The blowing of the whistle lowers the pantograph. Both power and hand brakes are fitted, there being 12 brake shoes in all. The braking effect is equivalent to 80 per cent. of the adherent weight.

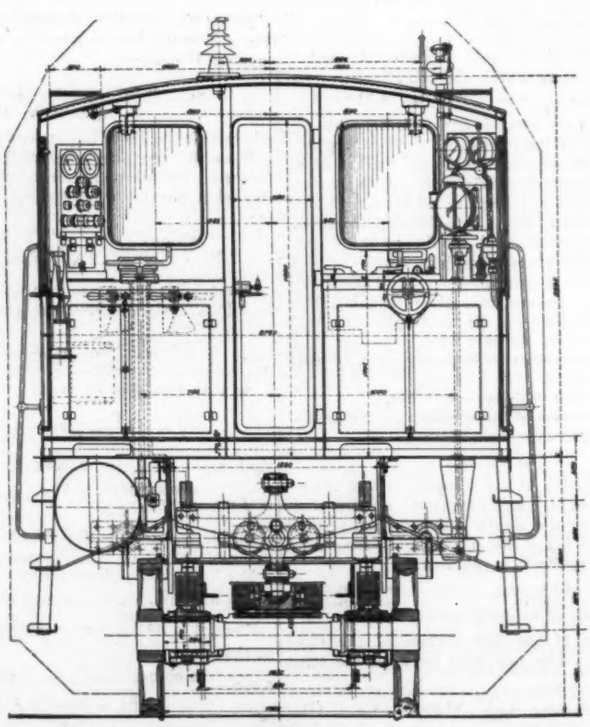


FIG. 5.

The two motors are able to exert 675 h.p. on continuous rating and 825 h.p. for 1½ hours. They are of the compensated series type, and each have 12 poles. Reversing is obtained by changing the direction of the excitation current, which operation is carried out by an electro-pneumatic commutator mounted above the motors. The double motor arrangement, which has been adopted mainly for mechanical reasons, necessitates a double control equipment in order to ensure a proper distribution of the power between the different driving axles. The arrangement incidentally is of advantage in reducing the weight and number of spare parts which have to be provided. The system also permits of the employment of contactor control, the banks of 12 contactors for each motor giving a range of 23 speeds. Locomotives supplied by the Oerlikon Company to the Loetschberg and other railways are equipped with similar contactor control, and have been in successful service for a number of years. The control arrangements have been entirely successful. The contactors are controlled electro-pneumatically, or can, in case of need, be operated by hand.

There are two main transformers of the air-cooled type. Each is connected to its corresponding motor through a contactor in series with a current transformer and a self inductance. The current transformer supplies current to an automatic cut-out. In general the two circuits, formed each of a transformer and motor, are connected in series. A group commutator placed above the transformers permits, however, other connections to be made. Thus each circuit may be completely isolated from the other. This permits one to be cut out in case of breakdown, while the other may continue working. In this condition the locomotive may still develop full speed, but of course, with only half the normal tractive effort. Another connection permits one transformer to supply the two motors. In this case the locomotive develops normal tractive effort at half-speed. The high-tension circuit consists of the two pantographs with their disconnecting switches and over-voltage discharges, two disconnecting switches for the transformers, two current transformers, and two earthing connections.

The pantographs have a working range of height between 4·8 m. and 7 m. They are operated by compressed air, a hand pump being fitted for emergency use. The disconnecting switches can be operated from inside the locomotive, and are interlocked with the door of the high-tension cabin. These main disconnecting switches are of the oil-break type operated electro-pneumatically, and have automatic overload and no-voltage attachments. The various auxiliary equipment fitted to the locomotive consists of two air compressors, ventilating fans, and a motor converter set, connected with a battery of accumulators. All auxiliary apparatus is operated by a 100-volt circuit fed from the battery. The air compressors supply at 5 atmospheres to 7 atmospheres, and are started and stopped by an automatic regulator operating the turns of the pressure in the air receiver. A heating circuit of 500 volts is tapped by the main transformer, and is used for heating the water. The maximum current is 400 amperes. Multiple control is fitted and two locomotives may be driven together with one control.

The 2-4-4-2 type locomotive has in the main the same arrangement of gear and control as the one described above, and need not be dealt with in detail. This locomotive, however, is fitted with gear permitting recuperation when braking or running down hill. The locomotive is illustrated in Fig. 7, on page 740. The electrical gear is arranged in both cases for a line voltage of 15,000, but transformer connections are fitted permitting operation at 7,500 volts. The 2-6-2 locomotive hauling a train of 200·7 metric tons on a gradient of 2·7 per cent. accelerated from standing to 32 miles an hour in 150 seconds. Drawbar pulls up to 24,000 lb. were recorded. The maximum power exerted was 2,160 brake horse-power at 35 miles an hour. The 2-4-4-2 locomotive on trial handled a train of 304·4 metric tons (exclusive of the weight of the locomotive). A drawbar pull of 37,000 lb. was recorded.

THE INSTITUTION OF MECHANICAL ENGINEERS.

AN ordinary general meeting—the last of the session—of the above Institution, was held on Friday last, May 30, at the Instituton of Civil Engineers, Great George-street, Westminster, the president, Dr. Hopkinson, occupying the chair. The president, during the preliminary business remarked that at the previous meeting a telegram had been despatched to members of the Institution in India, congratulating them on the prospect of a Society of Engineers being established in that Dependency. A letter confirming the message was also sent to Sir Thomas Holland, chairman of the inauguration meeting. In the meanwhile, Sir Thomas had replied to the effect that the members were greatly encouraged by the receipt of the telegram, and that the action which the Institution had taken was likely to conduce to an increase of members in India and strengthen the position there in every way.

[THE MECHANICAL PROPERTIES OF STEEL.]

Discussion was then resumed on the paper entitled "The Mechanical Properties of Steel, with some Consideration of the Question of Brittleness," by Dr. W. H. Hatfield, which was read and partly discussed at the meeting on the 2nd ult.

Dr. W. Rosenhain was the first speaker. He considered that the main point of the paper was that our methods of testing metals, steel in particular, required a great deal of further study and investigation. Until the mechanism by which a piece of steel failed in the testing machine and the mechanism by which it failed in service were known, it was necessary to use caution in applying the results of any method of testing. Agreeing so far with Dr. Hatfield, he desired, for the purposes of discussion, to emphasise points of difference rather than of agreement; although there was a good substratum of agreement. Dr. Hatfield had remarked: "It would appear that those tests are most instructive concerning the ultimate behaviour of the steel which nearest approximate to, or reproduce, the conditions under which the steel has to serve." He regarded the proposition as plausible, but untrue. It was impracticable to imitate the conditions under which metal served in practice; one factor or another had to be accentuated to such an extent that the proportionality between the results obtained and the service conditions imitated broke down. In his opinion, a test was valuable according as it measured, some fundamental property of the material. The simpler the test and the more complete the isolation of one physical property, the more reliable the results. To translate these results into prediction of the behaviour of a material in practice, required a good deal more knowledge than was yet possessed. To aim at imitation tests was to aim at something apt to mislead.

Dr. Hatfield had stated that the tensile test was fundamental. He would inquire what conditions of service the tensile test resembled, and in what structure or machine a piece of steel was strained far above its elastic limit. The same question could be asked about the Arnold test. The next question was, What was the criterion of a good test? Any new test was useful if it showed some property not ascertainable by the old tests, and was so whether it imitated practical conditions or not. With the author's views on the notch-bar impact test he was in complete agreement, except in respect to the extent to which the information obtained was applicable to practical purposes. He considered the brief summary of the work by Hanson and himself, given in the paper, was somewhat misleading. In the first place the author's criticism of the work was based on a misconception as to the meaning of the terms "dynamic" and "static." Dr. Hatfield had quoted a sentence in which it was admitted that the dynamic test had been used in order to ascertain the qualities of the steel, of which the conditions of use might, in the ordinary sense, fairly be taken as static. There was no such thing as a static test. Most people who had heard the resounding bang with which a piece of steel in tension broke would realise that breaking was far from a static phenomenon. The explosion of a boiler plate also indicated something very far removed from a static phenomenon. Further on the author had quoted and accepted the view that it made no difference to the results obtained in a notched bar test whether these were arrived at dynamically or statically, *i.e.*, by gradual pressure; the work absorbed by rupture was the same in both cases. The objection to the notched bar impact test could not, therefore, be to the impact but to the notch. He would answer that the notch was only too prevalent in boiler plates and that all pieces of metal were provided with a large number of minute notches, the majority being caused by non-metallic enclosures in the surface of the metal. These might well be regarded as giving rise to stresses, the distribution of which was not very different from, and might be much worse than, those met with in the notched-bar bending test.

Dr. Rosenhain then referred to his paper which had been quoted by Dr. Hatfield.* It would be seen that the tensile figures for the steel concerned were practically unaffected by the heat treatment. In other words, the plate in the condition in which it had proved itself unable to withstand ordinary manufacturing operations, was neither worse nor better after normalising. From the tensile test it could not be argued that anything was seriously wrong with the steel, but yet the impact test gave extraordinarily low figures. When the steel was normalised, this figure was brought up to its proper value.

Dr. Rosenhain then exhibited a lantern slide showing the large ferrite crystals associated with the condition of the steel as received. When the steel was normalised the coarse ferrite structure disappeared and with it the low impact value; but by suitable treatment the coarse structure could be restored and the low impact value would reappear, the tensile values remaining practically unaltered. (The slide shown was similar for Fig. 5 of Dr. Rosenhain's paper already reproduced in our columns, as quoted above.)

Dr. Rosenhain proceeded to say that various normalising and cold-working operations performed on the steel and quoted in his paper, showed that severe cold-working, after annealing at 650 deg gave a good N.B. figure. But a low amount of cold work after normalising led to the production of the coarse ferrite crystals. Taking the results altogether it appeared that the coarser were the ferrite crystals the lower was the impact value, but the tensile figure was practically unaffected. With another material, less coarsely banded, the response to treatment was similar in nature, but not in degree.

Continuing, Dr. Rosenhain said that not only the author but others had contended that when criticising the properties of a material, that had failed, it should be shown that material of the same kind which had stood well in service did not possess similar defects. But a comparison with one sample of a material of that kind was useless. Engineers were aware that every defective part did not fail. The fact that a piece of material gave a good test result or a bad one, did not prove its reliability or safety in service. If the comparison were not with one or two, but with a hundred, the weight of evidence would be quite different. Further to indicate the value and importance of the evidence afforded by the notch-bar test, he would quote the case of a heat-treated nickel chrome steel forging. One such forging broke, under a test very slightly above its working load, in an extraordinarily brittle manner, into fragments. Pieces cut from the fragments gave normal results under tensile test, while notch-bar tests gave abnormally low results. On the material being heat-treated the tensile figures were practically unaffected, and the notch-bar results were brought up to normal value. Experiment showed, in the case of a number of such forgings, that with a proper notch-bar value, the material withstood not only service but test conditions extraordinarily well; whereas when there was failure under test conditions the notch-bar figure was invariably low. That evidence, although not conclusive, was very important.

Dr. Rosenhain argued therefore that there existed enough information about the notch-bar test to

* See ENGINEERING, vol. cv., p. 692, *et seq.*

create something more than suspicion of a material which gave a low figure. Of course a high notch-bar figure might be purchased at too great a cost; for instance, if the heat treatment required to produce it involved the risk of cracking. Other things being equal, however, the higher the notch-bar figure the greater the reliance he would place on the material. He regarded the notch-bar test as a criterion for judging between different phases of the same material, rather than as a test for discriminating between one material and another.

Referring to the distinction, made in the conclusions of the paper, between true brittleness and notch brittleness, it was necessary when distinguishing terms to define them. At the previous meeting Dr. Howe had desired the author to define brittleness, and Dr. Hatfield had recourse to the dictionary, but the speaker was not disposed to attach importance even to the best dictionary, in the matter of defining technical terms. As defined by Dr. Hatfield a thing was not truly brittle unless it proved so in the tensile test; if it gave good elongation and reduction of area it was not brittle, no matter what it did in the notch-bar test. The author had also given an example of brittleness, quoting as proof breakage under the blow of a hammer. Such a definition would not suffice. There were frequent cases in which a material gave a good tensile test and yet failed in practice. The difference between what Dr. Hatfield termed true brittleness and the speaker's interpretation of brittleness was one merely of degree, not of kind. Notch testing was merely a method whereby the piece became more sensitive to a particular mode of fracture; and the sharper the notch the more sensitive would the piece be to minute differences in properties.

In conclusion, Dr. Rosenhain again referred to the tensile test, regarded by the author as fundamental. Apparently the author was most interested in the elastic limit, rarely, if ever, determined. More than that, if the test were not a tensile test by the extensometer it would tell very little, since it was not a constant of the material, but depended upon the particular treatment which the material had undergone, and was not representative of the safe range under repetitive stresses which the material would withstand. Knowledge was required not so much of the ultimate stress, yield-point or elastic limit intension, but the safe range of the material for alternating stresses; that was the real, fundamental property, in regard to tension and compression, which was wanted. The researches of his colleague, Dr. Stanton, had shown that range to increase rapidly with the carbon content of the steel. In practical cases, considerable ductility was required, and as a measure of that ductility he would be inclined to use the notch test rather than the tensile test; it was more sensitive to certain minute changes in the steel which appeared to be of importance.

Professor W. E. Dalby expressed his agreement with the author in considering the tensile test fundamental. The question, however, turned upon the meaning of "tensile test." The tensile test, as ordinarily understood, told a very small part of the story which it could be made to tell.

To illustrate his meaning, Professor Dalby showed a number of lantern slides, illustrating extension curves obtained with his optical extensiometer. All the information that was obtained from an ordinary tensile test was the load at which the beam dropped, the maximum load and the line of fracture. The load at which fracture occurred was not known. By putting the pieces together the degree of extension could be revealed. All that was obtained from the tensile test was a half co-ordinate at three points on a diagram. With nothing more as a guide, it was not wonderful that some of the subtle properties of the material could not be found, nor was it surprising that engineers had to invent and try various tests, shock tests among others. To ask for a useful test of material, based on such meagre data, resembled an attempt to discriminate between an A1 and a C3 man merely by taking their heights, widths across the chest, and the heights of the left shoulder. If all the points of loading, from zero to break, could be got on to the table, data would be afforded for a very different estimate of the material.

The optical extensiometer curves showed the total load and the end of the diagram gave the load at the instant of fracture. Instead of three half co-ordinates, a complete set of points, one after the other, was given. The test was so sensitive that dealing with iron bar for instance, it was possible from the shape of the curve obtained to identify the works from which the iron emanated. The method provided a subtle means for detecting differences of heat treatment, and he was prepared to guarantee that if the four boiler-plate bars referred to by Dr. Rosenhain had been tested in accordance with the diagrams being exhibited, each of the four differences of state would have been brought out unmistakably, and with greater distinction than shown by the microphotographs. Various slides were exhibited by Professor Dalby showing extension curves obtained with copper, nickel-chrome steel and phosphor-bronze. In connection with this latter Professor Dalby observed that as soon as it became a question of testing alloys, faith in elasticity was small. They seemed to have an elastic constant, which appeared to vanish after a very small load was applied. The shape of the curve would be seen to be different from anything else. Manganese steel had a curve something like a piece of brass. The method of cracking was peculiar to the material.

Continuing, Professor Dalby said that except by the aid of a tensile test carried out in such a way as to make it posible to trace load and extension from no load to fracture, no idea could be obtained of the differences in shape and the vast field opened out for discriminating between different qualities of material. Carried out as he had described, he agreed with the author that the tensile test was a fundamental test. He might refer to a test he had made of two pieces cut out of the breach end and muzzle end of a gun tube. Upon testing he had found a difference in shape indicating possibly a difference in working. Believing that a shock test might afford information, he had a number of such tests made; the average of these, confirmed that there would be a slight weakness at one end as compared with the other. In conclusion he considered that Dr. Hatfield had done a valuable piece of work, but he would not go so far as him in describing the shock test as valueless. For the last three or four years he (the speaker) had been endeavouring to correlate these tests, and see whether one test would yield the information now only obtainable from two or three tests.

Dr. T. E. Stanton pointed out that the machine coupled with his name in the paper was not designed as part of the equipment for testing materials at the National Physical Laboratory, but was a special apparatus got out by Mr. Bairstow and himself when studying the effect of impact. It was necessary to find the effect of a small blow frequently repeated until the point was reached at which the material would not break with an unlimited number of blows. He had not ventured to assume that the number of blows was a measure of the useful toughness of the material. He believed that the machine had been taken up lately, and that users were satisfied that it furnished a rough measure of useful toughness. Engineers generally, when a material was put before them, required to know the maximum stress the material would stand without deformation, and whether the material was free from any tendency to crack at sharp corners—his definition of brittleness. He agreed with the author in regarding a tensile test in which there was a careful determination of the elastic limit as good enough to satisfy the first requirement in the case of materials not cold-worked, but considered the fatigue test gave the best information.

With regard to true brittleness he did not think the evidence available was adequate to settle the controversy which had arisen. He believed in the notch-bar test, but the evidence was sometimes difficult to meet. He had always thought, until recently, that material which was brittle in the notch-bar test had a tendency to crack at the sharp corners, but he had lately made experiments which did not confirm that view. He therefore felt that Dr. Hatfield's opinions had a good deal of backing. Early in his paper, Dr. Hatfield had remarked, in respect to the practice at the Brown-Firth laboratory: "In the first place the design of the part and its relation to other parts in the mechanism in which it serves, are carefully studied, together with the actual conditions of service, that is, the magnitude and manner of the stresses the part is called upon to withstand." He regarded this as excellent practice, which should be adopted everywhere. Taking, for instance, an aeronautical engine which gave good results in an endurance test. Although there were parts of the engine which would be heavily stressed, the material being good stood the test. Then a batch of weak material might come along and failure of a heavily stressed part occurred. This was taken out and sent to the laboratory, where, on inspection and examination, it was pronounced to be bad. That was in many cases the end of the matter, although, in his opinion, the matter should not end there. The facts should be brought home to the designer, which too often was not done.

Mr. C. E. Stromeyer was disappointed that the author had not been able to fulfil the hopes, raised by his introductory remarks, that he would explain why structures failed. No clue as to the cause of failure was furnished in connection with the one sample which had actually failed, and of which Dr. Hatfield had given the test figures. Dr. Hatfield had sent him a piece of the angle iron in question, and he (the speaker) had had it analysed. This analysis revealed impurity as probably the true cause of failure. Instead of containing only 0·04 per cent. of nitrogen it contained 0·17 per cent. He had, some years ago, carried out comparative tests on samples of failed plates which he had collected for about twenty years, the comparison being with good steel. None of the tests would, however, discriminate between reliable and unreliable steels. Hearing of Brownlie's tests for nitrogen, he had his steels analysed for nitrogen, and then found a sharp dividing line between the reliable and unreliable steels, depending on the relative quantities of phosphorus and nitrogen, *i.e.* 1 phosphorus plus 5 nitrogen, which together should not exceed 0·08. In the case of the angle-iron, having 0·04 per cent. phosphorus only 0·04 per cent. could be allowed for nitrogen, but the analysis showed 0·17 per cent.

The author had submitted 18 test results of 11 samples of steel, but the test most desirable was not given—the reliability test to show how the steels behaved in practice. There was one other test which Dr. Hatfield might care to take in hand, namely, the "blue heat" test. He had, during his examination of 27 steels, heated the samples to straw colour, and then bent them through an angle of 45 deg., subsequently putting them aside for a week or a fortnight. He had then straightened them and bent them backwards and forwards, as in the Arnold test. Of the bad steels 75 per cent. broke with the first or second blow, whereas, of the good steels not one failed in this manner. Again, on one occasion he found that certain samples of steel had given bad results as regards bending. The tests had been carried out on a winter's day, and, when he next had to go to the works, he thought he would make a comparison between the bending of samples at ordinary room temperature and in the cold. He found that all the samples stood the bending test satisfactorily at ordinary room temperature, but when put into freezing mixture the bad samples broke while the good samples were as good as ever. He repeated that test with the 27 steels, but the result was not very satisfactory. The bad steels showed the effect of cold more than the good, but the difference was not marked enough to be of value. He believed, however, that some such test would be useful particularly in relation to flying machines, which were exposed to extremely low temperatures.

Turning to the term "brittleness," Mr. Stromeyer regarded the word as unfortunate. What the term meant in ordinary practice was understood, but he preferred "unreliability." Even Dr. Stanton's definition of brittleness as depending on sharp corners was not wholly true in relation to engineering structures, where failures occurred, although there was not even a suspicion of sharp corners. He had known plates crack at drilled holes. [Dr. Stanton here remarked that he referred to "an abnormal tendency to crack."] Mr. Stromeyer

next alluded to a sample taken from a burst boiler shell plate. It was slightly curved on account of the curvature of the plate and the natural thing to do with mild steel was to straighten the test piece, but the sample broke at the first blow of the hammer. A little piece was planed off the two corners, and the sample, on being tested again, gave 16 per cent. elongation. Further, he had made a comparative test of Bessemer and acid open-hearth steels, and the tensile and cold-bending tests proved quite satisfactory. After waiting for two or three weeks he secured new samples, the edges of which were planed and a hole driven through the centre. On testing, the hole began to elongate and then the sample broke, below the hole and within ½ in. of it, right across, with a brittle fracture. He regarded that as "unreliability." That was Bessemer steel, and if steel containing nitrogen behaved in that way it was a material to be avoided. If nitrogen were introduced into open-hearth steel, the same remark would apply, assuming nitrogen to be the real cause of brittleness. He had received from Germany, before the war, certain samples of steel made by the basic open-hearth process from good steel scrap; other samples were made from Bessemer scrap and also of Bessemer steel. Tests showed hardly any difference between the Bessemer scrap and the Bessemer steel samples. What he feared was this, that people might be forced to use Bessemer scrap in the open-hearth furnace, and so introduce nitrogen and produce brittleness.

Mr. F. W. Harbord understood the author's argument to be that there were two series of tests. One of these was the tensile test which had been called "fundamental," a sort of specification test, giving sufficient information to enable engineers to carry out most of their structural work. On the other hand there was the impact test, which, although useful, was not yet raised to specification standard. Dr. Rosenhain apparently contended that the impact test would, if properly investigated, serve as a standard specification test, and had supported his contention by details of a chrome steel which, under bad treatment gave an impact value of 2½ to 4 while the well treated steel gave an impact value of 9. Other things being equal, to condemn parts on the basis of such a difference seemed absurd. It was well known that with certain steels, there would be a variation of more than 2 between the highest and lowest impact values. He considered that common sense was necessary, and it was unwise to go too fast. It was his opinion that impact tests were most useful. Manufacturers would, however, not condemn forgings on an impact test if the results of the other tests were satisfactory. Steels in rolled sections were small and could be heated uniformly. To take, however, a mass of steel, averaging 10 in. or 12 in. in diameter, heat treat it, and condemn the piece, was, he considered, an unjustifiable procedure.

Mr. J. E. Batey quoted from the paper the following passage: "Sauveur in commenting upon this considers that the crystalline growth of strained ferrite, when annealed below its critical range, resulting in the formation of large ferrite grains, naturally causes brittleness. It should, however, be remembered that Osmond and Cartaud have actually examined the mechanical properties of iron crystals of large sizes and found them to have considerable ductility, and one would judge comparative freedom from brittleness." He did not, however, consider that an examination of the crystals would reveal what Dr. Hatfield appeared to suggest. Professor Edwards had expressed the opinion that it would soon be possible to calculate from first principles some of the more important mechanical problems of metallic elements, and with this view he agreed. The electron theory, for instance, was now sufficiently developed to bring it to bear upon the question of the mechanical properties of metals. The cohesive force between the electron and the atom or corpuscle was the strongest force known, and was the very starting point in the mechanical properties of metals. Professor Sir J. J. Thomson had calculated that the energy within a cubic centimetre of metal, due to the collision of electrons, was equal to the energy developed by an electric power station of considerable size. Taken in conjunction with the statement that the passage of one ampere across a section of wire meant the passage of 8·79 by 10^{18} electrons per second, this affords some idea of the internal energy dealt with in metals. In applying the electron theory to the testing of steels, the tests must be either electric or magnetic or both; the former took account of the quantity of electrons passing through the samples, which the latter considered the momentum of the electrons. Again, the former dealt with the specific resistance of the sample, while the latter measured the area of magnetisation, by a curve, by having an electromagnet test of the sample, or by making a balance similar to the Kelvin balance. Should it be possible to make any of these tests to a sufficient degree of fineness, he believed the results would be valuable.

Mr. H. M. Duncan referred to the fact that Dr. Hatfield had urged that in examining a failure a successful part of a similar steel should also be examined, eliminating features common to both by a process of cancellation. He considered this course dangerous, as neglecting the fact that failures were, in most cases, due to the sum of many causes. The effect of say, coarse structure associated with some other defects mentioned might just turn the scale and cause a material to break. He would not, however, isolate coarse structure as the cause of failure. Referring to brittleness the definition "apt to break" was a good one. All steels were "apt to break" if stressed sufficiently high. Brittleness was a comparative term, not a definite one. He would refer to the case of a shaft end which broke after it had run successfully for eleven years. A study of the tests gave room for surprise that it had run at all, seeing what were the Izod, Stanton and Sankey figures. The steel showed considerable brittleness; yet by Dr. Hatfield's standard, it should, having run eleven years, be all right. He would direct attention to the fact that the static tests did not show much wrong with the material; they did not indicate closely the degree of brittleness. Engineers required a test which would indicate the degree of brittleness possessed by any part; they did not want to reject a forging, but they did want to be fairly certain that it would not break down in service.

He had personally found that the Sankey test would discriminate between degrees of brittleness in steel, whether due to faulty heat treatment, to insufficient work on the material, or to non-metallic inclusions, or even to incorrect selection of the ingot cast before forging. He would be prepared to pass any forging on the results of the Sankey test alone. Of course, it would be seen that the Sankey test gave approximately the yield point and the maximum stress, while the reduction of area and the elongation could also be obtained from it. Mr. Duncan then referred to a large forging which had a cavity in it. The forging had been turned nearly to size, when a small hole was noticed. It was decided to break the forging to see what was the matter. The cavity, resembling that of two soup plates put face to face, was revealed. It measured 3 in. across in a longitudinal direction. There were many difficulties incidental to large forgings, quite apart from ability to stand up to mechanical tests.

Dr. Hatfield, replying to the discussion, said he did not think there was much that he could say in reply that was not already said in the paper itself. He would, however, notice a few points. Dr. Rosenhain had criticised the paper less severely than he had anticipated. Indeed, there was no great difference of view. Dr. Rosenhain and he disagreed mainly as to the value of the results of the impact test, and then only on the application of the data. He had not written the paper with any idea of asserting that impact tests were of no use; any test which brought out information which no other test revealed must, obviously, be of value. It might be a long time, however, before the information could be placed. Just as the Izod or Charpy test brought out information—on which perhaps Dr. Rosenhain placed too much reliance—so did the Stanton or the Arnold or the Sankey test. He coupled the two former tests because the data derived from them was of a similar order and related to the same physical property, whereas the information given by the other three tests undoubtedly differed, the data yielded by one affording no indication of the information which the others would give. Replying to Mr. Stromeyer, Dr. Hatfield said that he had sent him a piece of the steel knowing that he (Mr. Stromeyer) would look for nitrogen. He had long disagreed from Mr. Stromeyer's view that nitrogen caused brittleness in steel, and would assure him that it was not the case. He would be willing to send the remainder of the angle-iron to Mr. Stromeyer, who could put it under the steam hammer or do anything with it, but he would not find it brittle. The material broke when handled by the structural engineer. It had been sent to the speaker as a piece of brittle steel; he believed it was brittle, and there his "apparent brittleness" came in. The balance of the piece could not be broken by the steam hammer. Dr. Hatfield reminded Mr. Stromeyer that in the manufacture of Bessemer steel nitrogen was blown through all the time, and that many railways had been laid with Bessemer steel. Many boilers had been made of Bessemer steel and done good service. Had not the acid Siemens process been invented, the Bessemer process would have done very well. All metallurgists would agree that nitrogen in steel did not cause brittleness, at all events, in the quantities met with in steel produced by any industrial operation.

The effect of cold, referred to by Mr. Stromeyer, was important and of interest to engineers dealing with the work of aeronautical design. In this connection he felt that Captain Sankey's test, carried out at 50 deg. below zero, would prove instructive. He believed that Sir Robert Hadfield and Dewar had experimented extensively on the strength of steels at very low temperature, bringing out the interesting fact that many steels progressively increased in their maximum tensile stress while their ductility decreased. One steel, a nickel steel, maintained the same standard of strength as it went down in temperature. Unfortunately the tests were tensile tests only, and the information which auxiliary tests might have yielded was not available.

Dr. Hatfield accepted Professor Howe's criticism of the use of the word "fundamental" in relation to the tensile test. He did hold the tensile test to be more trustworthily indicative than other tests of the fitness of the material for its purpose. With regard to the interpretation of "brittleness," words were certainly often used nowadays to convey a meaning which formerly they did not possess. Nevertheless, language should be kept as pure as possible. He thought that the definition "to break" or Dr. Stanton's definition, "tendency to crack"—a modified form of Dr. Johnson's definition—would sanction the retention of the word "brittle." As to "apparent brittleness," he had used that phrase to cover the case of sharp crystalline fracture in a broken part, which looked brittle, as a consequence of the manner in which it broke; but which if properly broken would not have the sharp crystalline appearance unless it really was brittle. He thought the discussion had justified his use of the term. It had also been suggested that "notched-bar brittleness" was an incorrect phrase. The brittleness of steel under the notched-bar test could not be indicated by any other form of test. He considered therefore that the term might stand.

As suggested in the paper, he would urge that engineers should take more interest in the work which a part was called upon to play from the stress point of view. If they studied the materials better, then, when a successful part was tested, valuable information would be obtained. Dr. Hatfield asked Mr. Duncan whether he knew that the shaft he spoke of would have failed had it been reasonably stressed? He submitted that Mr. Duncan did not know. Taking the evidence afforded by other cases he questioned whether it would have failed. The material was typical of a great deal of steel that was to-day put into important parts. It was essential to realise the physical, chemical, micrographic and mechanical properties of the steels in use, and if the paper had pushed home that fact alone it justified the work bestowed upon it. To-day large parts were made of steel having indifferent characteristics from a physical and mechanical point of view, but which might very well be made of better steels. The nickel-chrome steels had a

INTERNAL COMBUSTION ENGINES FOR SUBMARINES.

CONSTRUCTED BY MESSRS. FRANCO TOSI, ENGINEERS, LEGNANO, MILAN.

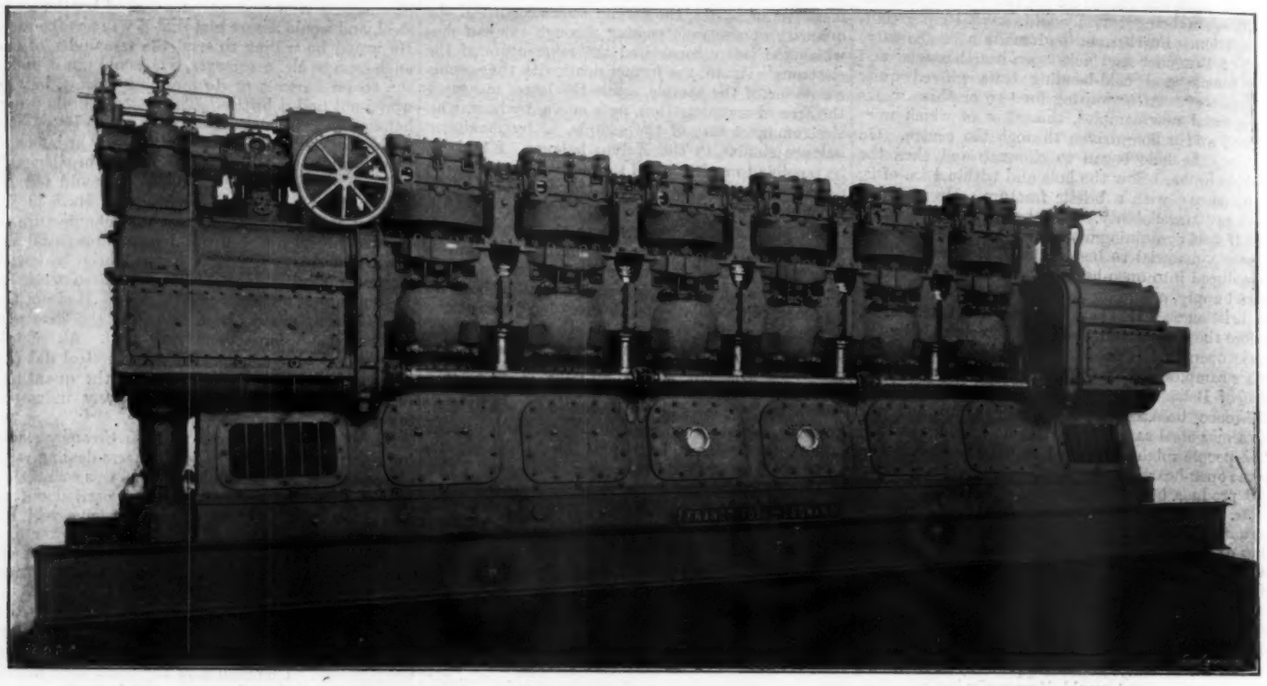


FIG. 1. SIX-CYLINDER TWO-CYCLE ENGINE.

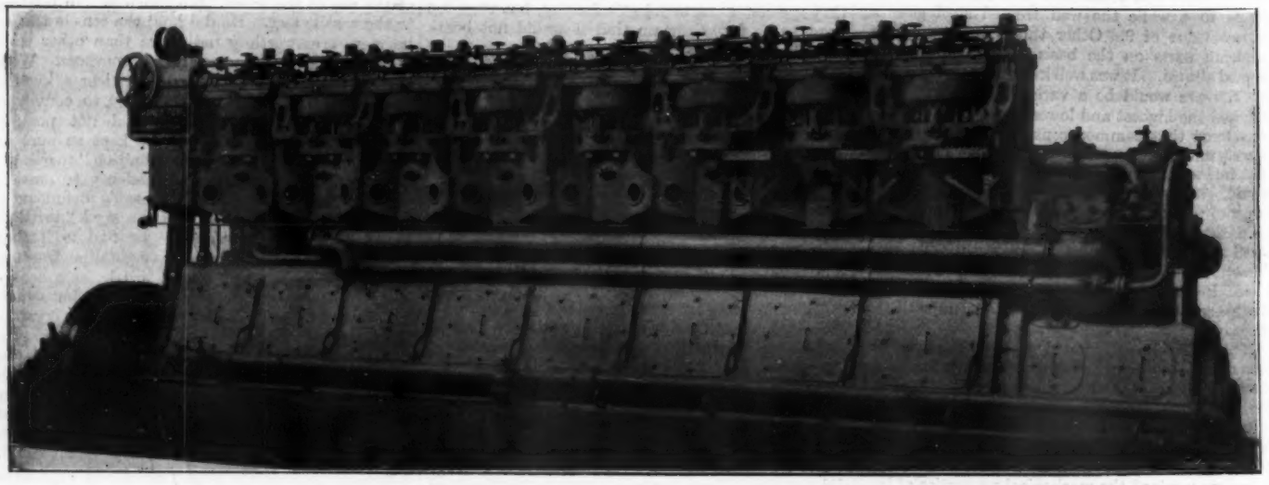


FIG. 2. EIGHT-CYLINDER FOUR-CYCLE ENGINE.

much greater application than was at present realised.

This terminated the discussion. A vote of thanks was then passed to the Institution of Civil Engineers for the use of the hall during the session. The president observed that there was every hope that the Institution of Mechanical Engineers might resume possession of their own house before the next session commenced. The president further said that the next ordinary meeting would take place in October of the present year, when he hoped to deliver his presidential address.

TOSI SUBMARINE ENGINES.

In view of the outstanding part played by submarines in the war, particulars of modern types of submarine engines have especial interest at the present time, and we publish herewith information relative to the Tosi submarine engine and a description of two engines—one a four-cycle, and one a two-cycle, to which reference was made when comparing the two cycles of operation in our article on "Two-Stroke *versus* Four-Stroke Internal Combustion Engines," in ENGINEERING, November 1, 1918, page 482. As was then pointed out, the comparison was particularly apt, since these two engines of equal power—1,300 b.h.p. per engine—followed in their design the same general character, as will be clear from an inspection of Figs. 1 and 2 above. Both engines being for submarine propulsion where space is strictly limited, are of the trunk piston type, totally enclosed with steel castings for the crank-case, and through-bolts to take the main tension load from off the main castings.

The two-cycle engine has six, and the four-cycle eight, working cylinders. In the case of the four-cycle a four-stage compressor is mounted at the forward end of the main engine, whilst the two-cycle has a scavenging pump and compressor pump at both ends of the main engine, with a scavenging air reservoir formed integral with the main framing.

The results of comprehensive trials with these two engines, together with the main deductions to be drawn therefrom, were given in our article already referred to, and we are now able to give these test results in detail (see table). It should be mentioned in passing that whilst the results of the four-cycle engine are excellent, those for the two-cycle are considerably inferior to the best present-day practice with two-cycle high-speed engines. Such a unique test, however, reflects great credit upon the builders and naturally attracts considerable interest to a detailed description of the design, and consideration in the following will chiefly be given to the more successful engine—the four-cycle eight-cylinder engine.

The conclusions arrived at as a result of these comprehensive trials were in favour of the four-cycle type on account of lower fuel and lubricating oil consumptions, greater flexibility, in that the principle of

INTERNAL COMBUSTION ENGINES FOR SUBMARINES.

CONSTRUCTED BY MESSRS. FRANCO TOSI, ENGINEERS, LEGNANO, MILAN.

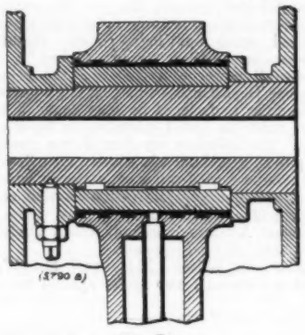


FIG. 3.

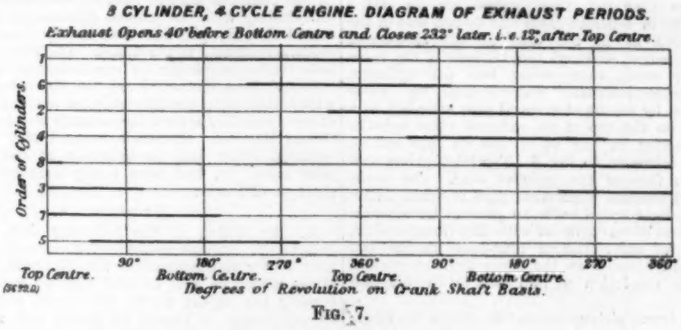


FIG. 7.

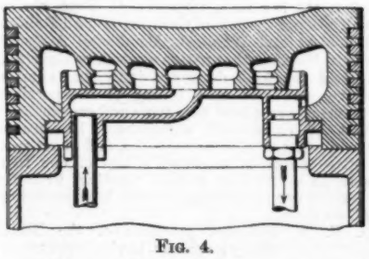


FIG. 4.

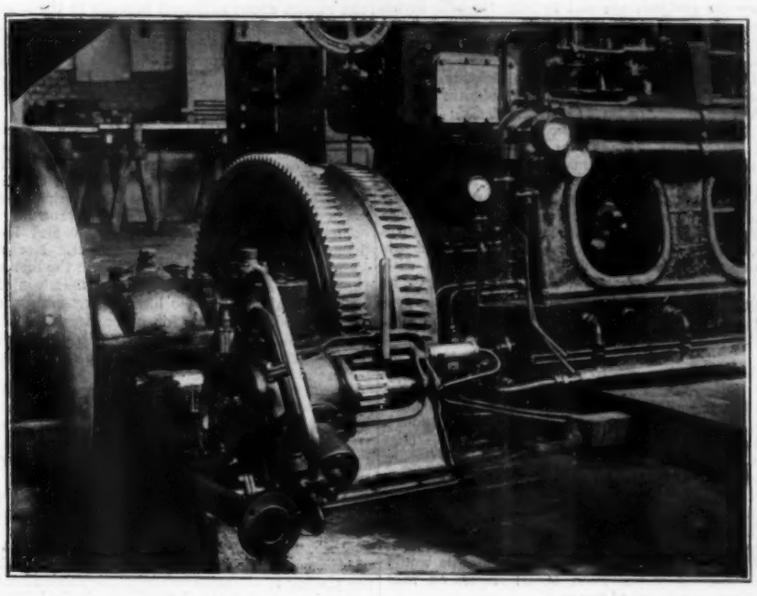


FIG. 8.

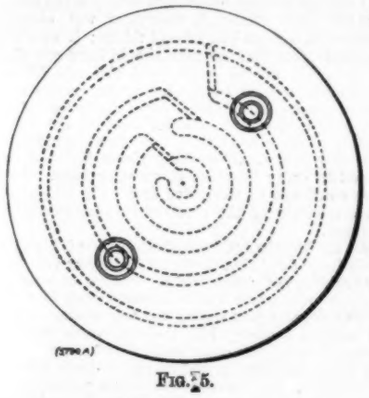


FIG. 5.

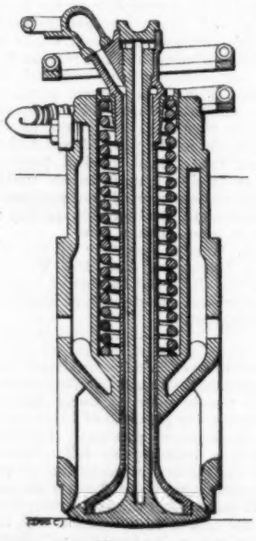


FIG. 6.

the four-stroke cycle makes possible the lowering of the speed of revolution to a smaller percentage of the full power speed than is the case with the two-stroke cycle. Also, as already explained more silent running, greater reliability, due in measure to the fact that the valve gear, &c., runs at half the speed of revolution of the crankshaft, and easier temperature conditions in the cylinder generally.

Whilst on this account Messrs. Tosi reverted to the four-cycle for all engines of small and medium powers, it is quite impossible to dogmatise where large powers are concerned. Messrs. Tosi have built a considerable number of very large two-cycle engines, which are running quite satisfactorily.

Many features of both of these engines are similar to those developed for the low-speed Tosi four-cycle Diesel engine already fully described in ENGINEERING, page 25 *ante*. The cylinder, crankcase and bedplate are of cast steel. The jackets of the cylinders are bolted together to give rigidity to the whole structure, and through bolts from the top of the framing to the bedplate relieve the jackets and crankcase castings of tension stresses. Ample inspection doors are provided for dismantling. The engine is force lubricated throughout. The crankshaft and connecting-rods are hollow to that end.

	Full Load.	Full Load.	Three-quarter Load.	Half Load.	Overload.
Type of engine	Two-cycle.	Four-cycle.	Four-cycle.	Four-cycle.	Four-cycle.
Number of cylinders ..	6	8	8	8	8
Duration of trial ..	—	36 hrs.	96 hrs.	12 hrs.	1 hr.
Power	1,300	1,300	950	650	1,485
Revolutions per minute	300	300	260	240	—
Fuel oil consumption lb. per brake horse-power hour	0·540	0·390	0·410	0·438	—
Lubricating oil consumption lb. per brake-horse-power hour ..	0·0334	0·0180	—	—	—

Each cylinder is provided with two inlet and two exhaust valves and one fuel injection valve. The inlet valves seat in the cylinder head, whilst the exhaust valves have separate cages. The valve gear is of the simplest type, since the engine is not reversible, the camshaft running along the top of the cylinders, being driven from the crankshaft through a vertical shaft and skew gearing, while the usual roller and lever mechanism gives the valves their motion. A four-stage compressor is driven from the forward end of the engine.

There are certain details of which we are enabled to give drawings. The gudgeon pin construction with a sleeve keyed on to the pin proper, which sleeve forms the bearing surface, is the same as with the slow-speed engine (see Fig. 3). This sleeve permits of a reduction in the gudgeon pin bearing pressure from some 2,000 lb. per square inch to 1,400 lb. per square inch. The bearing is force-lubricated by a supply of oil under pressure through the hollow connecting-rod. White metal is run into the solid eye of the connecting-rod and the gudgeon-pin is prevented from turning or coming out by the locking pin as shown.

The liner with its spiral rib, the cylinder head with one fuel injection, two exhaust and two inlet valves, the induction system drawing from a reservoir formed of the engine framings, the oil-cooled piston with spiral duct in the piston crown for the cooling oil entering at the centre and leaving at the sides, forced lubrication to all the bearings, engine starting means without air starting valves in the cylinder heads, separate fuel injection pumps for each cylinder so timed as to preclude coincidence of cylinder injection and pump delivery, valve gear driven by spiral gears and a vertical shaft, are all as described in detail in connection with the slow-speed engine in our issue of January 3 last, page 25. The special

construction of the piston crown to increase the efficiency of oil cooling is clearly shown in detail by Figs. 4 and 5 annexed.

There are, however, certain differences which must be recorded. Although two exhaust valves per cylinder are provided, these valves are, as stated above, placed in separate cages and do not seat in the cylinder head as in the case of the slow-speed engine. Moreover, although the diameter of the valve is relatively small, there being two per cylinder, each valve is internally water-cooled, the water supply being by means of a spiral pipe attached to a special nut on the top of the exhaust valve spindle. The construction of the valve and its cage will be clear from reference to Fig. 6. The inlet valves seat in the lower face of the cylinder head. The main water-cooled exhaust connecting pipe is fitted internally with a light spiral baffle to prevent interference of the exhaust of one cylinder with that from another, since with an eight-cylinder four-cycle engine two cylinders will exhaust at the same time at certain points in the revolution as indicated by the diagram Fig. 7.

The main trunk pistons are in two pieces, the upper carrying the seven piston rings and the lower serving to carry the gudgeon pin and to take the side thrust of the connecting rod. Whilst the two-cycle submarine and the slow-speed four-cycle engines are reversible, the high-speed four-cycle engine is not made reversible. In the case of these submarine engines reversal is carried out by declutching the main engines and then going astern on the main electric motors, which are fitted to all submarines, for under-water navigation. This means, in practice, that all manœuvring is done on the main electric motors.

The Tosi four-cycle submarine engine is not fitted with any starting device. In the case of the slow-speed engine, it will be remembered the low-pressure compressor cylinders were fitted with special piston valves, and relatively low-pressure compressed air operating in these two double-acting cylinders with cranks at 90 deg. was relied upon for starting. In starting these submarine engines either the main propelling electric motors or a separate starting engine can be used.

The case against starting air valves in the main cylinders was given when describing the slow-speed engine. The necessity for complete reliance on the main electric motors for starting is objectionable, on account of the big starting torque required, although in this case decompressing means are fitted. There is also the fact that the engine during the starting period is out of the control of the engineer, and is controlled from a different compartment, and may, due to negligence or faulty electric connection, be started in the astern direction of rotation instead of the ahead with possibly serious consequences. Furthermore, a breakdown of one of the main electric motors would prevent starting of the main Diesel engine on that shaft and so put it out of action.

For starting by compressed air a compressed air starting auxiliary engine has been designed (see Fig. 8). This engine has three radial cylinders, operated by compressed air, and it drives a pinion with teeth in the periphery of the flywheel. These teeth, although not clearly shown in the illustration, are slightly spiralled in order to keep in engagement so long as the servo-motor is the driver. When the main engine picks up on fuel and becomes the driver, the thrust of the spiral teeth pushes the pinion forward, and so out of engagement with the flywheel. The reduction ratio servo-motor to main engine is of the order 20 to 1 and full speed of the main engine 400 r.p.m. The illustration shows the compact nature of this starting device, which in this case serves a 400 h.p. submarine engine. For comparison it may be stated that the diameter of the flywheel, which also contains the main toggle clutch between the main engine and the electric motor, is approximately 4 ft. It should be stated that when this device is fitted the main engine is provided with decompressing gear so that the starting motor torque may suffice to give the main engine the speed of revolution requisite for picking up on fuel.

To return to the 1,300 b.h.p. engine, all the auxiliaries, as is not uncommon with submarine practice where electric power from batteries is always available, are driven by electric motors. These comprise the pumps for the cooling water and lubricating oil pumps. The weight of the engine works out at 66 lb. to 70 lb. per B.H.P.

ROYAL SOCIETY OF ARTS: ALBERT MEDAL.—With the approval of H.R.H. the Duke of Connaught, President of the Society, the council have awarded the society's Albert Medal for 1919 to Sir Oliver Lodge, D.Sc., F.R.S., "in recognition of his work as the pioneer of wireless telegraphy." The medal was instituted in 1864 to reward "distinguished service in promoting arts, manufactures and commerce." The presentation will be made by the Duke of Connaught, at Clarence House, to-day, the 6th inst.

INDUSTRIAL NOTES.

MR. A. W. STRAKER, secretary of the Northumberland Miners' Association, member of the Executive of the Miners' Federation, was examined at the sitting of the Coal Commission held on Wednesday, May 28, and dealing with the present decrease in coal output, stated that the pits had been largely overcrowded by soldiers returning to the mines. The mine owners had been under a pledge to reinstate the miners who returned from the services; on the other hand, he added, the miners strongly objected to the displacement of men who had served the country well in the mines during the war. A certain amount of overcrowding occurred which had an influence on output. Some pits, moreover, had been losing time owing to the shortage of trucks.

At the sitting of the following day, Thursday, May 29, Mr. Straker continued his evidence, and stated that under nationalisation the National Council of Mines would be able to deal with all questions concerning the export trade, and would have freedom of movement in regard to prices and rapidity of decision as to competition. The Council would give the export agent sufficient latitude in the lowering of prices to enable foreign competition to be met, in the same way as directors did now. The Council would, further, consider the vital interests of the consumers, but would not give them any representation on their body.

Mr. J. Winstone, president of the South Wales Miners' Federation, then said that six months after war broke out the South Wales coalowners found themselves with an unemployed balance of 23,000 men. After the signing of the armistice the South Wales mines had the full complement of men that were there when the war broke out. The overcrowding of the collieries, the want of development and industrial disputes had seriously affected output. Moreover, an idea had been gradually developing in the men's minds that it was right on their part to maintain the coal output within reasonable limits, presumably in order not to produce wealth for other people, and if the Commission, he added, did not take that point into consideration it would be missing one of the essential factors in the situation.

Mr. Joseph Shaw, K.C., speaking on behalf of the South Wales and Monmouthshire Coal Freighters' Association, stated that under private enterprise the British coal output had extended very rapidly during the last forty years, the percentage of increase being 123 in the United Kingdom and 250 for South Wales. The excellence of the management had kept the collieries fully employed. For a period of twenty years before the war only 480*l.* per annum, on an average, was paid for demurrage. It was the opinion of his association that nothing but disaster could follow the placing of the mines under Government control.

Speaking on behalf of the Scottish Coal Exporters' Association, Sir Daniel Stevenson said there was an impression among his colleagues that nationalisation in any form would greatly reduce the output of coal and consequently render impossible the maintenance of exports on pre-war bases. Should that occur, the railways and docks would lose the enormous revenue derived from the transport and handling of export coal, and a whole army of miners, coal trimmers, railway workers, dock labourers, sailors and engineers would be thrown out of work.

Sir Keith Price stated he had been responsible for the control of over 50 Government factories; he found these had been satisfactorily run, and the management and results did not compare unfavourably with private enterprise. Among his objections to Government control, however, was the weakness of any Government organisation in purchasing raw materials on competitive lines and in marketing its products; he could not see how this could be done satisfactorily on commercial lines without acute controversy.

The sitting of last Friday, May 30, opened with the evidence given by Mr. E. Smallwood, chairman of the Coal Merchants' Federation of Great Britain, in whose opinion any system of nationalisation of mines and minerals which interfered with the individual enterprise, oversight, experience and incentive of those connected with the industry would have a disastrous effect. The standardisation of coal and appliances was outside the range of possibility. Under the competitive system, the reward of the colliery owner was kept in check, whilst under State management the industry might be used for the purpose of raising large sums of money for revenue purposes. The present high price of fuel, he added, was largely due to the measure of State control now exercised.

After three miners' wives had given evidence as to housing accommodation, the Hon. F. M. B. Fisher, New Zealand Government, stated that New Zealand had nationalised many industries, including coal Mr. Webb had said that under Government there would be fewer strikes than under private ownership. Evidence from New Zealand would prove that that was wrong. During the national strike there, in 1913, the national coal miners and sailors in Government steamers did not hesitate to join the strikers. In 1890, the New Zealand railways, which were completely nationalised, went out in a body. Departmental regulations, he further stated, robbed a man of practically all power of initiative; the principle of Government Departments was that if you give a man power to take a decision he may make a mistake, hence in order to avoid mistakes he avoids taking decisions. He failed to see how it was possible unceasingly to shorten hours, increase wages, limit output and still compete with other countries in which these conditions did not apply. Nationalisation created a monopoly and a State monopoly was worse than a private one. A State monopoly could obviously be used for party political pressure.

Mr. Havelock Wilson, M.P., and Mr. W. Cash, chartered accountant, also spoke against nationalisation.

The Coal Commission resumed its sittings last Tuesday, the 3rd inst., when Mr. G. Rose, chairman of the National Council of Coal Trades and Rail-borne Coal Factors and Wholesale Merchants' Association, expressed the view that nationalisation or Government control of any kind destroyed individual effort and initiative, and created a feeling of irresponsibility. Government procedure was too cumbersome for the conduct of commercial enterprises. He instanced a case in which it took four months, and about twenty committee meetings involving a loss of one to two days to 15 or 20 men at each meeting, to settle a point which two business men would have agreed upon in half an hour.

Mr. E. S. Williams, president of the National Association of Colliery Managers, having 1,600 members and branches in every coalfield, said that in the interests of safety and efficiency, discipline was absolutely necessary in the working of coal mines; it was, therefore, imperative that one man should have sole charge and direction of the work, and the possibility of appealing to a joint committee would undermine all sense of responsibility and destroy discipline. In the past, pit committees had often asserted the right of preventing men from carrying out urgent and necessary work, and as a result working places had had to be stopped in order to make them safer later. A ship at sea could not be navigated under the joint control of a committee of the crew with representatives of the owner.

Mr. P. Muschamp, president-elect of the same association, added that the State had never yet proved its capability of managing a business successfully; the stupendous waste and mismanagement by the big spending departments during the war tended to prove that a great industry like the coal trade would be absolutely ruined if it came under Government control.

Sir John Maclaren, president of the Leeds Chamber of Commerce, put forward resolutions passed by the Chamber, which took exception to the Commission as not being a body fairly qualified to deal with the question; this, the resolutions said, ought to be settled in the national interests and not in that of either the miners or the owners; they objected, further, to nationalisation from the consumers' point of view. In importance, the interests of the consumers far outweighed those of either the miners or the owners. The excessive rise in the price of coal had resulted in so increasing the cost of finished products in this country that foreign manufacturers could undersell us and foreign customers would not purchase our goods. At the present time, steel for shipbuilding was 2*l.* per ton cheaper in America than here.

Mr. G. H. Wright, secretary of the Birmingham Chamber of Commerce, and Mr. W. F. Gardner, president of the Glasgow Chamber of Commerce, gave evidence to the same effect; other witnesses also spoke against nationalisation.

In a recent issue of *The Labour Gazette*, the Director of the Department of Labour Statistics gives information on the rise in rates of wages during the war. He states that in the first half of 1914, rates of wages, which for three years previously had been rising, were showing a tendency to fall. Soon after the outbreak of war the downward movement was checked and few changes were recorded in the last five months of 1914. Towards the end of the year, however, the increase in the cost of food, coupled with the growing demand for labour arising from the withdrawals of men from industrial occupations into the Army, led to applications for increases in wages, and early in 1915 war bonuses or war wages increases were granted to railway servants and shipyard workers generally, and to large bodies of workmen in the principal centres of

the engineering trade. The movement gradually spread to other trades.

Dealing with the industries which are of special interest to our readers, it is stated that until 1917, the additions to, or deductions from, rates of wages in the coal-mining industry mostly took the form of percentages, calculated on the "basis" or "standard" rates of a particular date; and the rates paid in the summer of that year varied, in different coalfields, from 28 per cent. to 47 per cent. above those paid in August, 1914. In September, 1917, flat-rate war grants of 1*s.* 6*d.* a day in the case of workers 16 years of age and over, and 9*d.* a day for those under 16 years, were added under a decision of the Controller of Coal Mines, and in 1918 these amounts were doubled as from the end of June. In accordance with the recommendations of the Coal Industry Commission a further increase of 2*s.* per day for men and 1*s.* for boys has been granted to date from January 9, 1919. For the great majority of the men employed the general increases over pre-war rates in the principal coalfields are now as follow:—

Northumberland	47 per cent., plus 5*s.* per day.
South Wales	46 ,, ,,
Scotland	43 ,, ,,
Durham, Yorks., Lancs. and Midlands	32 ,, ,,
Bristol, Radstock and Forest of Dean	28 to 33 per cent., plus 5*s.* per day.

In some cases the average increase in wages has been rather greater than these figures indicate, owing to the grant of special advances to particular classes of men.

At iron mines and open works, where wages generally are regulated by the selling prices of pig-iron, the increases during the war have varied in different districts. On the average, rates of wages (including bonuses) have been rather more than doubled.

In the paragraph covering iron and steel manufacture, the article says that blast furnacemen in Durham and Cleveland have had increases in wages equivalent to nearly 68 per cent. on their pre-war rates and, in addition, war wage advances or bonuses ranging from 2*s.* 3*d.* to 2*s.* 10*d.* per shift. In Scotland, they have received percentage increases equivalent to 51 per cent. on their pre-war wages and a bonus of 3*s.* 9*d.* per shift. Iron and steel millmen in the principal districts have mostly had increases of 113 per cent. to 117·5 per cent. on pre-war rates, and iron puddlers increases of corresponding amounts. Steel smelters, pitmen, &c., generally have received advances ranging for the higher paid men from 60 per cent. to 77 per cent. on pre-war rates. In the case of the lower-paid men, the increase has varied according to the pre-war rates, being over 150 per cent. for labourers rated at, say, 22*s.* 6*d.* per week before the war.

Dealing with engineering and shipbuilding, it is stated that the increases represent different percentages in the case of different classes of workers, according to the variations in the pre-war rates of pay. The following figures are the average amounts of increase (inclusive of the 12½ per cent. bonus) granted from August 4, 1914, up to the end of April, 1919, on the district time rates for men in certain representative occupations in a number of the principal engineering and shipbuilding centres, and the equivalent percentage increases over pre-war rates:—

	s.	*d.*	Per cent.
Engineering—			
Fitters and turners	37	11	98
Iron moulders	38	2	92
Labourers	35	5	156
Shipbuilding—			
Platers	37	4	93
Riveters	37	0	98
Shipwrights	37	7	91
Labourers	35	2	154

In addition to these increases in wages, the weekly hours have been reduced to 47 (usually from 53 or 54) without any reduction in weekly time rates.

Railway servants generally, engaged in the traffic sections, have received flat rate advances, during the war, amounting to 33*s.* per week for men, and 16*s.* 6*d.* per week for boys. Men in the railway engineering, &c., shops receive the same general increase as men in the engineering trade.

Dock labourers at the principal ports have mostly received advances amounting to about 6*s.* to 8*s.* per day. For seamen the cash rates for able seamen and firemen, which were usually 5*l.* and 5*l.* 10*s.* per month, respectively, in the first half of 1914, have been raised to 11*l.* 10*s.* for able seamen and 12*l.* for firemen. In addition to these rates a special war-risk bonus, amounting to 3*l.* per month in the case of vessels on monthly articles, was granted in October, 1918, to men on vessels trading within the war zone, and has since been extended for the period covered by the Wages (Temporary Regulation) Act. In the carting industry, and in the tramway and omnibus services, a general war wage advance of 30*s.* per week over pre-war rates has been granted.

In addition to these increases in wages, a shorter working week has been adopted, generally of 44 hours for dock labourers and 48 hours for railwaymen, carters, tramway and omnibus servants, &c., without any reduction in weekly wages.

Speaking on Wednesday, May 28, at a meeting held at Harrods' Stores in connection with a scheme for establishing an association for the Advancement of Education in Industry and Commerce, Lord Leverhulme stated that there had grown up in the mind of the British workman a false idea that capital was his enemy and that his interests were best served by following a policy of ca' canny at his work. The majority of workmen in London to-day believed in the policy of making one job serve two men when it ought to serve one. This was a false doctrine, and it had resulted in the astounding fact that wages were lower in England than in any other English-speaking country. The country where wages were highest was the United States, and the United States could produce a motor car for 100*l.* less than the corresponding car could be produced, on lower wages, in this country. It was not high wages, but the output which came into play. In spite of the obstacle of protection, wages and the standard of comfort were higher in America than here, and yet the British people thought America was proceeding on wrong lines. Mr. Gompers had publicly stated that America had discarded the ca' canny policy, and an American had pointed out the significant fact that whilst in England 85 per cent. of our labour was trade unionist, in America the proportion was only 15 per cent. Personally, he (Lord Leverhulme) believed trade unions to be necessary, but if they would realise that trade could be carried out only by the efficiency of their members securing intensive production without fatigue, then this country might be brought to the front line of production.

THE STILL ENGINE.

TO THE EDITOR OF ENGINEERING.

SIR,—The combined internal-combustion and steam engine referred to on page 708 of your last issue is certainly not a novelty. I built several engines, very similar to the one you describe, in 1902 and 1903, and no doubt others have done the same before or since. It is not difficult by the method mentioned to get rather more work per pound of fuel burnt than is possible with an ordinary internal-combustion engine and to attain self-starting and reversibility, but the extra complication and increased cost is hardly justified by the saving effected. The real "snag," however, lies in the latent heat of evaporation of water.

If you have an internal-combustion engine developing 20 h.p. in total energy of combustion, you will get about 6 h.p. on the brake and about 13 h.p. dissipated in the jacket and exhaust. Supposing it were possible (which it isn't) to use the whole of this waste heat in raising steam, only about 6 per cent. could, theoretically, be recovered as useful work. In other words, since the thermal efficiency of a small reciprocating steam engine and boiler does not exceed about 6 per cent., only about 6 per cent. of 13 h.p. or, say, 0·8 h.p. would, theoretically, be available to assist the internal-combustion engine. In practice you do not get as much as this. With larger engines better results may be attained, but the limit is reached, even theoretically, when about 12 per cent. or 14 per cent. of the jacket and exhaust heat is recovered as work, owing, as I have already said, to the losses due to latent heat.

From the power point of view I got better results by using petrol instead of water in the jackets and petrol vapour instead of steam in the second cylinder (or the other end of the same cylinder), but, while this eliminates any trouble due to chemical action on the cylinder walls, it necessitates the additional complication of a condenser and, of course, double glands with the space between them connected to the condenser to avoid danger from leaks.

I experienced no trouble with lubrication, simply using Price's oil for air-cooled engines.

Yours faithfully,
CHARLES W. KAY.

Fairoak, Elm-road, Woking, June 2, 1919.

THE POSITION OF THE OFFICIAL IN ENGINEERING AND OTHER WORK.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with great interest the letters referring to the above, dating from your issue of December 20 last, and I am of opinion that it is quite time something was done to form an "Officials' Organisation" to further, and protect the interests of all professional men serving under the representative or general manager of a railway, or other engineering concern.

From long experience I have found that after the first three years service an increase in salary is given, and after the elapse of another three years an expected increase is not forthcoming, and as years roll by the salary still remains stationary. All this time the official is compelled to cut down expenses to such an extent that the legitimate repairs to engines and rolling-stock cannot be properly carried out, and thus he has not a free hand to look after the department of which he is the head and for which he is held responsible. The general manager gets a salary three times as big as that of the professional man serving under him, and this would seem the reason why the latter is only too often looked upon by him as a subordinate and treated with scant respect.

The official having to work shop hours and overtime without extra pay, leisure hours are practically unknown to him; so to secure more equitable treatment it is to be hoped that through the medium of ENGINEERING, this may be accomplished.

Yours truly,
May 2, 1919. "SPANISH MAIN."

DRAUGHTSMEN.

TO THE EDITOR OF ENGINEERING.

SIR,—The statement of the editor of *The Draughtsman* is quite correct, and if such an inference as he fears were drawn from my letter, I should be sorry. There is only one point in "Scrutator's" letter upon which a little explanation may be worth while. Affiliation to the Trades Union Congress is a trades union matter, and no ballot is legally required. The *desirability* of taking a ballot upon this point was a matter only within the competence of the Representative Council. Affiliation to the Labour Party involves political action, and inasmuch as trades union funds may not be spent for political purposes, such money as is so spent must be contributed voluntarily, and a ballot, consequently, would have been a legal necessity.

If your correspondents wish to discuss these matters further I shall be happy to continue in the columns of *The Draughtsman*.

Yours faithfully,
ERNEST H. WALKER
(Chairman Executive, A.E. and S.D.).

THE ATLANTIC FLIGHT.

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of May 30, Sir George Greenhill gives us his revised views on long-distance flying. Although, under the instruction of Mr. Glauert, his treatment of the subject has improved, his conclusions cannot but be a source of amusement to those having some acquaintance with aviation. Unfortunately, there are many people who imagine the pronouncements of an eminent personage, irrespective of their subject, are to be considered as *ex cathedra*.

An investigation of heavy howitzers, in the light of the elementary trajectory (*in vacuo*) would hardly be received with enthusiasm in ballistic circles; but Sir George's treatment of the Atlantic flight is closely akin to this. He arrives at the conclusion that the limiting range of the Handley-Page and "other machines where any figures are divulged which can be subjected to the test of arithmetical calculation" is not more than 1,000 miles. This amounts to giving the lie direct to those responsible for the calculation of the ranges of the Atlantic machines. It is a serious statement when made by a responsible person.

It is not necessary to deal in detail with the erroneous assumption on which Sir George Greenhill's results are based, since his statistical paragraphs are self-condemnatory. Further, there is little doubt that a non-stop flight exceeding 2,000 miles will have been made before the end of the current year. The following results already accomplished, will also assist us to appreciate the statement that "It seems prudent . . . to assign a diameter of action of the H/A flying machine of not more than 800 miles."

(1) N.C. 4. Trepassey to Azores, 1,540 miles, non-stop. (This machine had to rise from the water, and was necessarily less favourably situated as regards fuel, deadweight ratio, than the Handley-Page or other land machines.)

(2) Sopwith trials. Brooklands–Bristol circuits, 900 miles non-stop on half petrol capacity.

(3) Sopwith flight from St. John's, approximately 1,000 miles non-stop. When the machine was compelled to descend by cooling trouble, about half the petrol had been used.

Yours faithfully,
JOHN D. NORTH,
June 4, 1919. F.R.Ae.S., F.R.Met.Soc.

GOVERNMENT OF INDIA, PATENT OFFICE JOURNAL.—We have received from the Superintendent, Government Printing, Calcutta, a copy of the "Indian Patent Office Journal," for 1918, dealing with applications for patents and for registration of designs under the Indian Patents and Designs Act, 1911, and containing also a list of the earlier extant exclusive privileges and patents obtained under the Inventions and Designs Act, 1888. It supersedes the three quarterly journals which were issued in 1918, and is issued at the price of 1 rupee, or 1*s.* 6*d.*, by the superintendent.

BRITISH OUTPUT OF IRON AND STEEL.—The output of hematite pig-iron; basic pig-iron; foundry, forge and other qualities and of alloys amounted to 150,000 tons in the week ending April 5, to 154,000 tons in that ending April 12, and to 152,000 tons in that ending April 19. The furnaces in blast were, respectively, 291, 295 and 294 in number. Taking the last week above referred to, the output of hematite pig-iron was 56,000 tons produced in 100 blast furnaces, and that of basic pig-iron 52,000 tons produced in 83 blast furnaces. For the same weeks, the outputs of steel ingots and castings were, respectively, 172,000 tons, 173,000 tons and 166,000 tons. The total output of pig-iron of all classes for the week ending May 3 was 151,000 tons produced in 290 blast furnaces, and that of steel ingots and castings 157,000 tons.

THE VICKERS-VIMY PASSENGER-CARRYING AEROPLANE.

CONSTRUCTED BY MESSRS. VICKERS LIMITED, ENGINEERS, WEYBRIDGE.

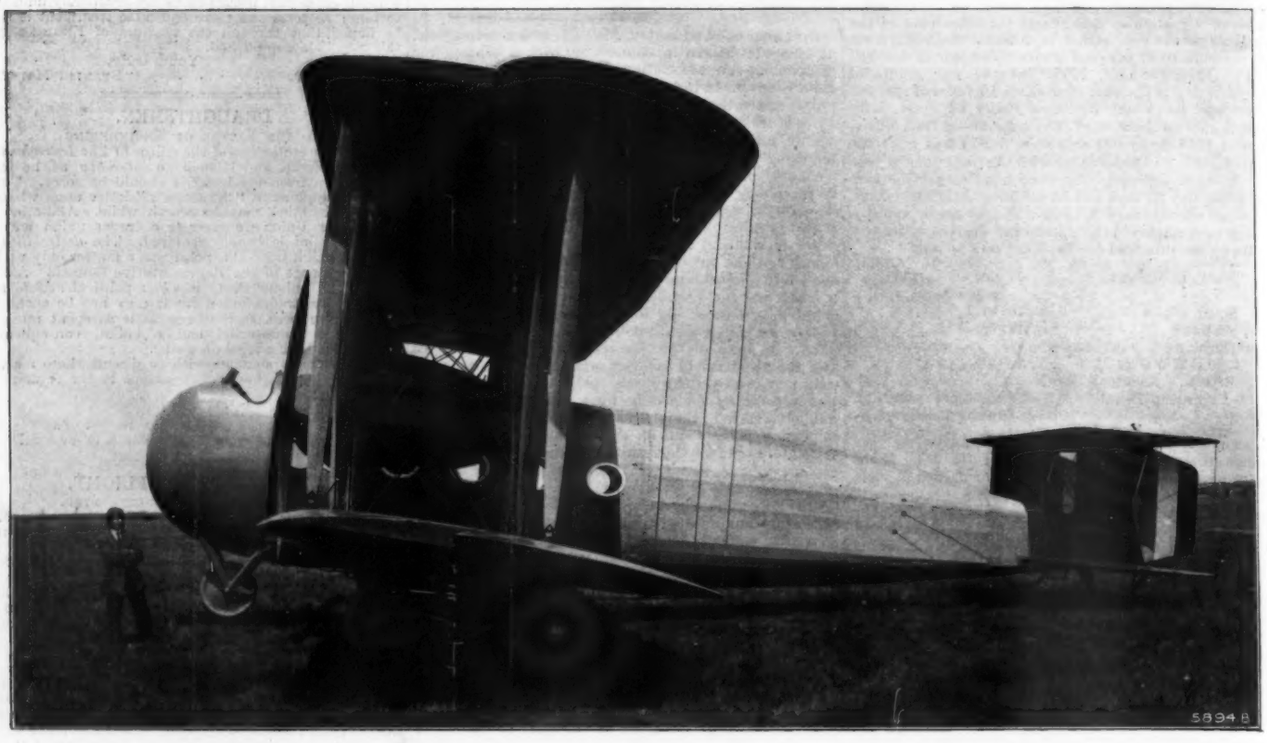


FIG. 1.

On page 604, *ante*, we gave an account of the Vimy-Rolls bombing aeroplane designed and constructed by Messrs. Vickers, Limited, Aviation Department, and reproduced some photographs of this machine as modified for the Transatlantic flight. We are now able to illustrate the same machine adapted for conveying passengers or goods, for which purpose the only alterations made have been the fitting of an entirely new design of fuselage and the provision of dual control. The wings, control and stabilising surfaces, and other details of the machine, are exactly the same as those of the bomber above referred to, and as particulars of these have already been given in our previous article we need not deal with them here.

The photograph reproduced in Fig. 1 above gives a good idea of the appearance of the machine, and the drawings, Figs. 3, 4 and 5, on the opposite page, clearly show its general arrangement. The most noticeable feature in all these illustrations is the great depth of the fuselage, which, it will be seen, is of elliptical section and of excellent stream-line form. Although it is of much larger section than that of the bomber, the performance of the passenger-carrying machine is practically identical with that of the bomber, owing to the extremely good aerodynamical properties of the passenger fuselage. An inspection of Figs. 4 and 5 will show that the fuselage is divided into three distinct sections, of which the central is utilised for the passenger cabin, providing accommodation for 10 persons. This cabin, which is the most interesting part of the machine, is of a special form of "monocoque" construction, which we shall describe later. The nose portion, in front of the cabin, is also of "monocoque" construction, and in the upper part of this is situated the pilot's cockpit, in which either two pilots, or one pilot and a passenger, can be carried. The machine will thus carry 12 persons in all. The after part of the fuselage is of wood and swaged tie-rod construction, with longerons made under Vickers-Ryan patents, and is generally similar to that adopted for the bombing machine, except that it is fitted with a light fairing leading off in easy lines from the rear bulkhead of the cabin to the tail.

Fig. 6 is a view of the nearly finished cabin looking forward, and Fig. 7 is a similar view taken during the course of construction. Fig. 8 shows the external appearance of the cabin during construction. As will be seen from Fig. 6, armchairs, built up of aluminium castings and comfortably upholstered, are placed on both sides of the cabin leaving a central gangway of sufficient width for easy movement. Light hand-luggage can be stowed out of the way in cupboards provided for the purpose at the end of the cabin. Circular windows are fitted near each seat, and two doors are placed on the port side, one in front of the main planes and the other close to the trailing edge. These doors are made watertight so that the machine will float if forced to descend into the sea, and to provide for this emergency a trap door has been fitted on top of the cabin to enable the passengers to leave in this way if necessary. The forward door, it should be explained, is intended to admit bulky goods when the machine is used for this class of transport. It is not conveniently accessible when the engines are running owing to the proximity of the propellers. Passengers enter the cabin through the rear door, which is of triangular shape and hinged at the top. Its peculiar shape is due to the fact that a bracing bar is fitted to take the shear stress, which would otherwise be carried by the part of the outer casing cut away for the door opening. Height and speed indicators are fitted in the cabin for the use of passengers who may be sufficiently interested to observe them, and a telephone is provided for communication between the pilot and passengers. Arrangements can be made for heating and ventilating the cabin to suit any climatic conditions.

FIG. 2.

The cabin is built up of elliptical rings of box section, composed of ash flanges steamed to the correct shape, with webs of spruce glued and screwed to the flanges. One of these rings, cut through to illustrate its construction, is shown in Fig. 2. The outer cover of the cabin is composed of "Consuta" patent ply wood, which is built up of thin layers of spruce with the grain placed diagonally, and then glued and sewn together with thread, the rows of stitching being about 1½ in. apart. This material, which is claimed to be much stronger than ordinary plywood, is made by Messrs. S. E. Saunders, Limited, of Cowes, which firm is now allied with the Vickers Company. Ash stiffeners, clearly visible in Figs. 6 and 7, are placed at intervals between the main box rings to give additional support to the outer casing. The outer casing, of course, takes the whole of the shear stress on the fuselage, and the tensile and compressive stresses due to bending are carried by ash longerons, which can best be seen in Fig. 7, running along the side of the cabin at the floor level, and also just above the windows. An inspection of Fig. 4 will show that these longerons are connected to those of the rear portion of the fuselage at the back of the cabin, and are also continued right round the nose in front. The fittings by which the connection between the longerons is affected are visible in Fig. 8. The cabin is attached to the upper main plane by two pairs of raking struts, the fittings for which are just visible in Fig. 8. To secure the lower main plane to the cabin two ash members run transversely under the floor in line with the wing spars, and to the end of these members steel fittings are attached by means of through bolts. To these fittings corresponding fittings on the spars are bolted.

The inside dimensions of the cabin are 6 ft. 2 in.

THE VICKERS-VIMY PASSENGER-CARRYING AEROPLANE.

CONSTRUCTED BY MESSRS. VICKERS LIMITED, ENGINEERS, WEYBRIDGE.

Fig. 3.

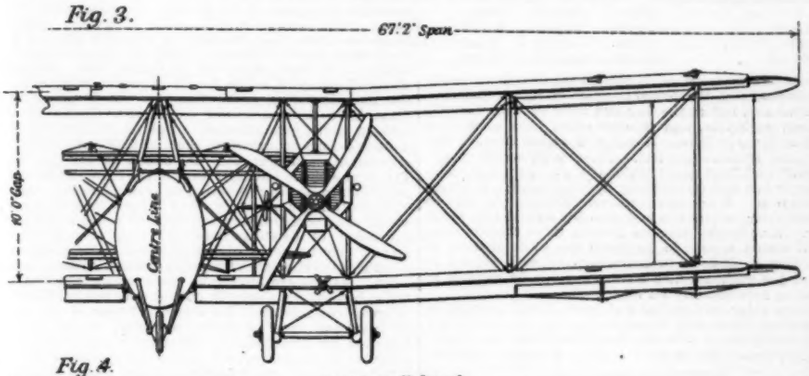


Fig. 4.

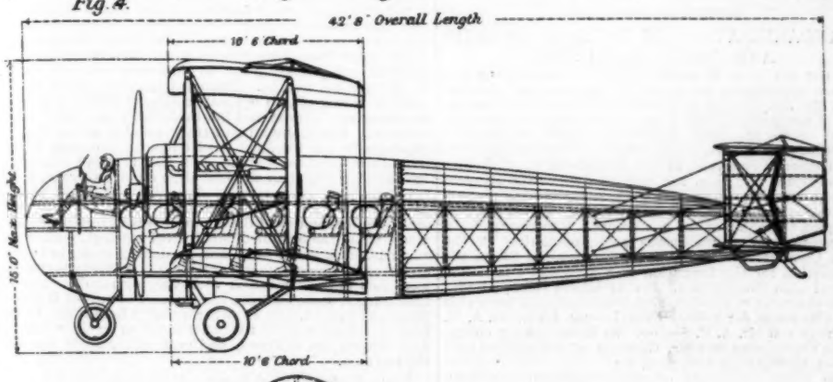


Fig. 5.

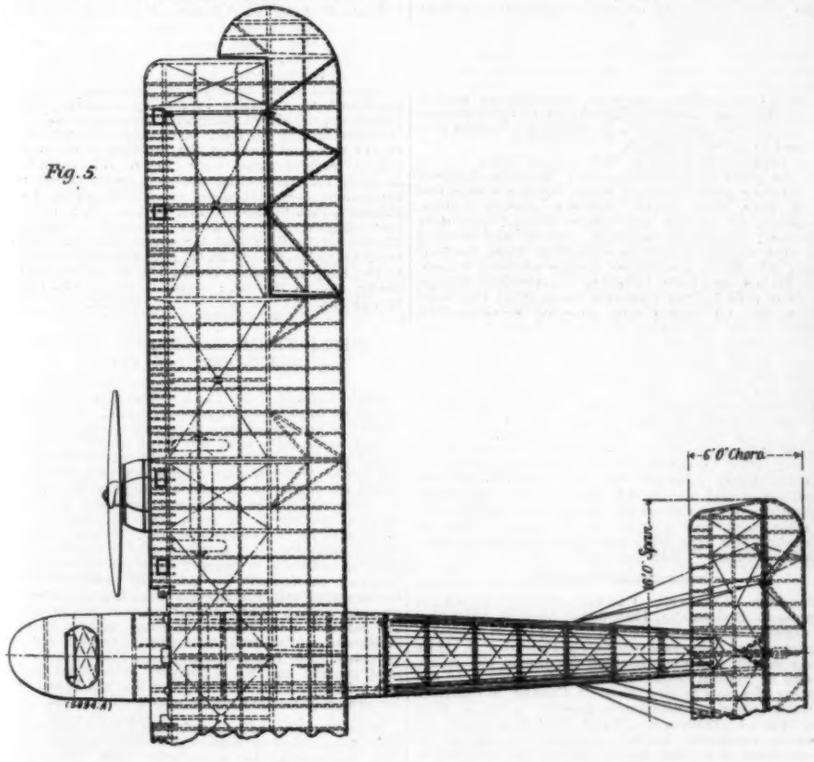


FIG. 6.

FIG. 7.

FIG. 8.

high, 16 ft. long, and 4 ft. 2 in. wide. The floor area is 53 sq. ft., and the volumetric capacity 300 cub. ft., or 7½ cub. tons. The seats are easily removable, so that, if required, the cabin space can be used for the conveyance of goods or mails. The maximum weight that can be carried in this way is 2,500 lb. The weight of the machine empty, but with water in the radiators, is 7,292 lb. Oil and petrol for 5 hours, and reserve water, make up another 1,520 lb., so that the total weight of the machine loaded amounts to 11,312 lb., or just over 5 tons. In no part of the structure has strength been sacrificed for lightness, the designed factor of safety being 5 throughout. As previously stated, the performance of the machine is very similar to that of the bomber. With two 375-h.p. Rolls-Royce "Eagle," Mark VIII engines, the speed near the ground is 110 m.p.h., falling to 103 m.p.h. at 6,000 ft., and to 99 m.p.h. at 10,000 ft. A height of 6,000 ft. is reached in 17 minutes, while a climb to 10,000 ft. takes 48 minutes. With the engines slightly throttled down to a speed of 90 m.p.h., the petrol consumption of the two engines is 35 gallons per hour, and the oil consumption 2 gallons per hour. The capacity of the tanks is such that the petrol and oil supply will last for 5 hours under these conditions, so that a total distance of 450 miles can be covered without landing. The endurance can, however, be increased by sacrificing some of the useful load. If,

for instance, it is required to cover a distance of 900 miles without stopping, the useful load can be reduced to 1,000 lb., or, say, 5 passengers and baggage. The machine will fly quite well with one engine at a speed of 70 m.p.h., and the landing speed is 45 m.p.h.—the same as that of the bomber. As shown in Figs. 1, 3 and 4, an extra wheel is fitted under the nose of the fuselage to diminish the effects of a bad landing.

Although only very recently completed the machine has proved to be quite satisfactory in the air. On Saturday last it was flown from Dartford to Hendon, a distance of 25 miles, in 15 minutes, with a load of eight passengers, returning after carrying out a large number of exhibition flights at the latter aerodrome without a mishap of any kind.

FOREIGN PUBLICATIONS AND THE PATENT OFFICE LIBRARY.

In recent correspondence [see A. R. Low on "Critical Speeds of Shafts," ENGINEERING, May 9, 1919, page 601] reference was made to a Swiss technical publication to be found in the Patent Office Library, and it was stated that a copy could probably be obtained from the publishers at Zurich. It is not generally known that under the present practice photographic copies of such documents can be obtained at the Patent Office Library. Under the old practice permission was commonly given for a professional photographer to be brought to the Library for the purpose of photographing documents, but now these are officially made to order quickly and at a low rate. The cost for a negative (that is a print showing white letters on a black ground) is 1*s.* for a half sheet, size 13 in. by 9 in., and 2*s.* for a whole sheet, size 13 in. by 18 in. For a positive the charges are double. Application for such copies is made upon forms to be obtained in the Library, these are filled in, left at the Enquiry Office, and the fee is paid at the same time.

One has to state the purpose for which the copy is required, because as regards work in which copyrights subsists, applications cannot be accepted for any purpose which would infringe copyright under section 2, paragraph 1 of the Copyright Act, 1911, unless the consent of the owner of the copyright is obtained. This section, however, provides that infringement of copyright does not occur in any case dealing with work for the purposes of private study, research, criticism, review, and newspaper summary, so that photographing for such purposes is permissible.

In practice it usually takes two or three days to secure a photograph in the manner described, which is much less than the time required for obtaining a print of a foreign work, even if such can be secured, and it is very often more expeditious to obtain a photograph of, say, an American specification in this way rather than to send to America for a print. This also applies to other foreign specifications, and in this connection it may be noted that in addition to the printed specifications, indexes, and other publications of the Patent Office, the Library contains a collection of the leading British and foreign scientific journals, transactions of learned societies, and text-books of science and art, and the full or abridged patent specifications of the following countries:—Argentine Republic, Austria, Barbados, Belgium, Bermudas, Canada, Cape of Good Hope, Commonwealth of Australia, Denmark, Finland, France, German Empire, Gold Coast, Grenada, Hungary, India, Italy, Japan, Mauritius, Mexico, Natal, New South Wales, New Zealand, Norway, Portugal, Queensland, Roumania, Russia, St. Lucia, St. Vincent, South Australia, Straits Settlements, Sweden, Switzerland, Tasmania, Trinidad, United States of America, Victoria, and Western Australia.

COAL IN MALAYA.

It is only a few years since coal was discovered in the Federated Malay States, and the mines at Rawang, Selangor, the property of Malayan Collieries, Limited, have been working only a little over three years. Yet the output last year amounted to 168,740 tons, and the States have now entered the category of countries exporting coal.

The output for the past three years was as follows: 1916, 101,846 tons; 1917, 155,279 tons; and 1918, 168,740 tons. Operations were hindered by the impossibility of procuring all the necessary plant from England, though every assistance was given by the local Priority Committee. Shortness of labour was also experienced, and an epidemic of influenza had a restricting effect on output. The South Mine in the main seam is now down to 1,700 ft. on the incline, and the North Mine in the same seam to 1,550 ft.

The colliery sidings have been extended in order to deal with coal from the open-cast workings, and further extensions are in hand.

The output from the mines for 1918 was distributed as follows: Federated Malay States Railways, 67,437 tons; mines, 66,500 tons; other Federated Malay States' consumers, 14,915 tons; exported, 19,888 tons.

Mr. W. Eyre Kenny, Senior Warden of Mines, Federated Malay States, in his general remarks on mining operations in the country, states: As in 1917, coal from outside sources was practically unprocurable for use in the mines (he is referring chiefly to the tin mines), and but for the supply of local coal the fuel situation would have been very serious. As nearly as can be ascertained, the tonnage of fuel consumed on mines in the past three years was as follows:—

	1916.	1917.	1918.
Coal	72,952	62,044	66,290
Oil	3,107	2,538	3,488
Wood	645,280	646,285	741,357

There was an increase in fuel costs, though it should be remarked that the actual increase on mines that used imported coal before the war and later on took Rawang coal was negligible, and in some cases 1918 costs were less than those in 1914. It was with regard to wood fuel that most pressure was felt. There is an ample supply of wood fuel, but great difficulty was experienced in getting it out and distributing it, there being a shortage of transport. When the Malayan Collieries are able to increase their output, the fuel situation will become much easier. Mr. Kenny suggests that in these days of dear fuel, it would appear to be worth the while of users of machinery in Malaya to make inquiry with regard to suction gas engines which have proved to be capable of operating economically on local coal.

Chinese mine owners have already shown interest in steam plant fitted with superheaters, and in view of fuel supply conditions it is highly desirable that all new plant should be of such design as to secure a good fuel economy.

STANDARDISATION OF DETAILS OF SHIPS AND THEIR MACHINERY.

With the view of securing for our shipbuilding and marine engineering industries all the benefits desirable from the adoption of an efficient system of standardisation of component parts, a very representative conference of the official nominees of the Government, classification societies, ship owners, shipbuilders, and marine engineers was convened last year, at the instance of the President of the Board of Trade, and was held under the auspices of the British Engineering Standards Association. Sir Archibald Denny, the chairman of the association, occupied the chair at the conference. The result of the discussion was a unanimous recommendation to the Main Committee of the British Engineering Standards Association for the formation of a Sectional Committee to deal with this subject. Sir Archibald Denny, Bart., is the chairman of the Sectional Committee and has as his Vice-Chairman, Sir Aubrey Brocklebank, Bart., Mr. A. M. Kennedy and Mr. A. E. Seaton, the latter taking charge of the engineering and Mr. Kennedy of the shipbuilders' section dealing with deck gear, &c.

The usual procedure of the association has been followed in that a number of Panel Committees are being formed to put forward the preliminary proposals for submission to the respective sub-committees. These panels will meet in various districts, and thus have the advantage of being able to call upon superintending engineers and captains, designers, draughtsmen and, in fact, all those intimately connected with the construction and use of the various parts in relation to which it is proposed to set up standards.

The following is a list of the subjects being studied from the point of standardisation: Bollards, fairleads and mooring pipes, hawsers, ropes, rigging screws and rigging gear, boat davits, derricks, derrick fittings, stanchions, all ladders and ladder fittings, and deck machinery, windlasses, capstans, winches and steering gear, deck and hatch fittings, watertight doors, manhole covers, side lights, ventilators, bunker and coal fittings, cabin fittings and beds, including electric light fittings, not dealt with by the Electrical Committee, plumbers' fittings and all piping and pumping arrangements, anchors, cables, and chains, also pipe flanges, steel pipes, cast-iron and steel cocks and valves, gunmetal and brass fittings, boiler furnaces and tubes, condenser tubes, ferrules and copper tubes, shafting and propeller bosses, gauges and similar appliances. Bilge ballast and ship side fittings, composition of brasses and bronzes, ladders and platforms and gratings of engine rooms.

It is quite recognised that a considerable amount of very valuable work has already been carried out in this connection by others outside of the association, but it is confidently expected that this work will be fully co-ordinated with the British standards and that those Institutions or committees which have been doing highly valuable work will consent to co-operate with the association and thus bring standardisation in the shipbuilding industry "under one roof."

Textile Machines, Canada.—It is stated in Appraisers' Bulletin No. 1906, dated April 30, 1919, that by decision of the members of the Board of Customs, Departmental Memorandum dated December 7, 1910, ruling certain machines adapted for use in the manufacture of woollen textile fabrics under tariff item 453 as being of a class or kind made in Canada, is cancelled and the following substituted therefor to be in effect from May 1, 1919, viz.: Until further advised, the following machines, specially adapted for use in the manufacture of woollen textile fabrics, may be entered under tariff item 468: Shake willow or wool waste duster; rag dusters; warping machines; wool opener and mixer; soaping and wringing machine; dyeing machines of all kinds; drum spool winders and pressure drum spool winders; yarn reel, with counting motion; dead spindle spooler and bobbin stand; spooling and doubling machines; Fearnaught pickers; ring twisters. The following textile machines are considered to be of a class or kind made in Canada: Galashiels fulling mills; kicker fulling mills; cloth washing machines; duster willow (other than self-delivery machine); card creels.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The steel trades show weak patches, but taken in the aggregate, business appears to be expanding, and despite export restrictions and the unsatisfactory nature of railway facilities, progress is being made with the cultivation of foreign markets. Inquiries show that Sheffield is securing quite a nice proportion of trade formerly done by German establishments. The chief drawback to future trade expansion unquestionably is to be found in works congestion in the manufacturing area. Some of the foremost steel firms have devised minor extensions, chiefly to file-making plant, but, generally speaking, the steel-making industries are so crowded that further extensions are impossible until new sites are added to the city area. This is one of the foremost aims of the Sheffield Development Committee in promoting an area extension scheme. Special attention is being paid to the provision of suitable works sites with railway facilities to accommodate the expansion of existing industry, and, if possible, to attract new branches of manufacture. Complaints are general of the shortage of supplies of finished and common irons. Makers are buying as freely as the position will allow, but the deficiency in output does not enable them to cover commitments far ahead. Prices of all classes of iron are firm. Further revisions in an upward direction are forecasted in the near future. Somewhat irregular conditions prevail in the heavy steel branches. A very healthy tone is manifest in the trades supplying steel and tools to the shipbuilding yards. Home requirements are on the increase, and export buyers are coming much more freely into the market. Makers of railway material are preparing for an improved state of trade in the coming months. Though immediate needs show a slight falling-off, an optimistic view is taken of future requirements. India and South America are improving markets. Spain, Japan and Italy are also taking heavy tonnages of the Sheffield steel output. Tramway steel is a fairly active section, but the crucible furnaces are working less than the half time on the average, and trade in high-speed steel is flat. On the other hand, pressure on the lighter branches tends to increase. Makers of carbon steel drills report a welcome improvement, while the output of small steel castings, malleable castings, files, saws, farm and gardening tools, is being absorbed by immediate requirements. A shorter working week has been introduced with varying results. Some steel makers state that the former level of output is more than maintained, but in other cases, where staffs have been increased to allow the introducton of an eight-hours' day, output has declined, and costs accordingly are on the increase.

South Yorkshire Coal Trade.—Best steam hards are in active demand on home account, and there is a limited quantity going away for export. Cobbles and nuts are firmly held. Practically the whole of the output continues to be required to meet contract commitments. A somewhat easier tendency in the market for slacks is attributed to a decline in quality resulting from the practice at the pits of filling with shovels instead of forks, and thus causing much dirt to be sent along with the fuel. In the house-coal section the position is much easier. Public requirements have fallen off considerably. Stocking for the coming winter is under consideration. Quotations:—Best branch handpicked, 27*s.* to 28*s.* Barnsley best Silkstone, 27*s.* to 27*s.* 6*d.*; Derbyshire best brights, 25*s.* to 26*s.*; Derbyshire house coal, 22*s.* 6*d.* to 23*s.* 6*d.*; best large nuts, 22*s.* 6*d.* to 23*s.* 6*d.* small nuts, 21*s.* 6*d.* to 22*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* 9*d.* to 22*s.* 9*d.*; best slacks, 18*s.* to 19*s.* 6*d.*; seconds, 16*s.* to 18*s.*; smalls, 13*s.* to 14*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is little new to report of the Cleveland pig-iron trade. Foundry kind cannot be purchased for this month's delivery, the June output being fully sold, but forge quality is comparatively plentiful, and consequently rather cheaper than the better descriptions. Buyers are prepared to place orders for supply to the end of the year, but producers are not inclined to enter into contracts for delivery beyond the third. A good deal of July–September business on home account is passing. The truck shortage, though considerably less acute than it has been, is still such as seriously to hamper distribution. Continental demand, particularly on behalf of neutrals is heavy, but business with customers abroad is small, due to the sparing way in which export licences are issued, and the marked disinclination of some makers to sell to foreigners whilst iron is urgently needed for home purposes. For home consumption, No. 3 g.m.b. Cleveland pig-iron and No. 4 foundry both stand at 160*s.*, No. 4 forge is 158*s.* to 159*s.*, and No. 1 is 164*s.*; whilst for export quotations are 5*s.* above these rates.

Hematite Iron.—As regards the East Coast hematite department there appears to be no relief to the stringency that has existed for some little time. Iron is most difficult to purchase, several makers being so well sold that they refuse to entertain further business for the present. Nos. 1, 2 and 3 are 190*s.* for home use and 195*s.* for export, and No. 1 is 192*s.* 6*d.* for home use and 197*s.* 6*d.* for export.

Foreign Ore.—There is decidedly more doing in foreign ore and prices are moving upward. Consumers are reluctant to pay the rising rates, but as their stocks are low and their contracts running out they are obliged to buy. Prices vary greatly, but 52*s.* c.i.f. Tees may

be given as a fair quotation for best rubio now that the freight from Bilbao is fully 25*s.*

Coke.—Coke is firm and rather expected to advance. Average blast-furnace kind is 39*s.* at the ovens, and low phosphorus sort 41*s.* 6*d.* at the ovens.

Manufactured Iron and Steel.—There is no new feature of moment in finished iron and steel. Manufacturers are pretty well sold, and demand is fairly good. Considerable inquiry from abroad is reported, and in the home trade there is most activity in shipbuilding requisites and railway material. For export steel plates are 18*l.* f.o.b., and other quotations for shipment abroad are a little above the following, which are among the principal market rates for home use:—Common iron bars, 20*l.* 10*s.*; marked bars, 23*l.*; strip iron, 21*l.* 15*s.*; steel ship, bridge and tank plates, 17*l.*; steel angles, 16*l.* 10*s.*; steel joists, 16*l.* 10*s.*; and heavy steel rails, 13*l.*

Shipments of Iron and Steel.—May shipments of iron and steel from the port of Middlesbrough exceeded expectation. According to official returns they totalled 58,402 tons, of which 51,348 tons went abroad and 7,054 tons went coastwise. Last month's loadings of pig-iron amounted to 22,622 tons, 18,102 tons of which went to foreign ports, and 4,520 tons coastwise. Of the 970 tons of manufactured iron shipped in May, 943 tons went to foreign ports and 27 tons coastwise. Steel cleared last month reached 34,810 tons, 32,303 tons going to foreign ports and 2,507 tons coastwise. The principal receivers of pig-iron were Japan, 5,248 tons; Italy, 4,705 tons; and Belgium, 4,222 tons. India took the most manufactured iron and steel, importing 307 tons of the former and 12,300 tons of the latter. Amongst other principal customers for steel were: Japan, 3,977 tons; New Zealand, 3,872 tons; and Italy, 2,393 tons.

Ironworkers' Wages.—The average net selling price of iron bars and angles for the two months ending April 30 last having been certified by the accountants to the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England at 18*l.* 5*s.* 7·68*d.*, as compared with 16*l.* 12*s.* 11·34*d.* for the previous two months, puddling and other forge and mill wages are advanced by 15 per cent. for the months of June and July.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—No change of any moment falls to be recorded in the steel trade of Scotland during the past week, and the ruling conditions are unaltered. Reports show that the demand for ship plates is still very heavy, and that deliveries are anxiously awaited by consumers. Large quantities are also desired for export, but with the heavy home demand and also the difficulty of securing transport the foreign trade is not yet on a large scale. The same thing applies to general steel material, although merchants are hopeful of obtaining better supplies in the near future and of making satisfactory arrangements for export. The scarcity of hematite iron continues, and the price is strong, with an upward tendency, so that steel of all kinds is likewise very firm. New business is still largely confined to the more immediate requirements, but it is becoming more evident that certain schemes cannot be indefinitely put off, and that inquiries will be launched on the market at no distant date. The demand for sectional material is not very heavy, and the majority of the makers would welcome an increase in this branch of the industry. Producers of steel sheets are still well placed for orders and activity is general, but no improvement can be noted with regard to the galvanised sheet trade.

Malleable Iron Trade.—The conditions in the malleable iron trade of the West of Scotland have undergone very little change, but fresh business is rather better. The various works continue to be well employed, largely on contracts already booked, and makers are hopeful of a steady increase in new orders before very long. Prices continue firm, with no immediate prospect of easing, but consumers are still holding back. "Crown" bars are quoted round 20*l.* 2*s.* 6*d.* per ton, net, Glasgow, and 20*l.* 10*s.* per ton, net, f.o.b. Glasgow.

Scottish Pig-Iron Trade.—The demands for Scotch pig-iron is as strong as ever, and orders are plentiful despite the firmness of prices. The output is not equal to the heavy demand, and, in fact, the home market is absorbing the bulk of what is being produced, and very little is available for shipment. Makers are reluctant to booking much forward business at the present time, as it is very probable that quotations may be officially advanced during the next few weeks.

Scotch Shipbuilding.—The Scotch shipbuilding returns for the past month are not without interest, and although the figures of new tonnage launched are not large, the number of vessels for the Government forms the lion's share. The totals for the different districts are as follow:—

	Tons.
The Clyde, 19 vessels	17,444
The Forth, 5 vessels	7,613
The Tay, 2 vessels	2,173
The Dee, 9 vessels	1,464
Total, 35 vessels	**28,694**

The Clyde total for the year to date is now 107 vessels, of 180,899 tons, which is the lowest total since 1909—omitting of course, the war years, which cannot be taken into account. Out of the total Scotch output of 35 vessels only 6 were actually for private owners, and the remainder were made up as follows: 1 light cruiser, 4 destroyers, 2 submarines, 1 gunboat, 1 survey vessel, 4 minesweepers, 2 barges, 2 lighters, 1 drifter, 4 trawlers, 2 tugs, 3 standard steamers, and 1 motor boat, all for the Admiralty, and 1 concrete ship for the Shipping Controller. Shipbuilders' order books are fairly well filled at present, but during the past month very few new contracts were reported. The high costs now prevailing may be retarding the placing of fresh contracts, but it is difficult to see any immediate prospect of prices easing off, especially with raw materials so dear and also so scarce. It is generally anticipated that when peace is finally fixed up a more confident tone will prevail and business will open out more freely.

Nationalisation and its Effect on Scotch Industries.—A special meeting of the Glasgow Chamber of Commerce was held last Friday, when consideration was given to the effect which nationalisation of the coal mines would have on the many industries of the West of Scotland. Resolutions strongly protesting against the proposal of nationalisation were submitted from various associations. These protested against the proposal of nationalisation of the coal mines, as such a course was likely to raise the price of coal and decrease the output, which would seriously affect both the home and the export trade, increasing the cost of commodities, and creating unemployment; and, further, that an adequate and cheap supply of coal was essential, and this could best be obtained under the incentive of private ownership. After the various communications from all the above associations had been read, a resolution was submitted to the meeting declaring that the directors of the Glasgow Chamber of Commerce, as representing the trades and industries of Glasgow and the West of Scotland, were strongly opposed to nationalisation of the coal mines. The resolution was adopted unanimously.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—Supplies of all descriptions of Cardiff large and small steam coals have been scarce due to sectional pit stoppages caused by disputes, and also by congestion at the various local docks. Arrivals of tonnage have not been so heavy of late, but even so, there are sufficient vessels already in the dock to tax the loading capacity of available tips. Lack of engine power on the railways has retarded the return of empty wagons, and in a number of instances collieries have had to effect temporary stoppages, owing to the non-arrival of expected trucks. It will be recalled that the Central Executive Committee for the Supply of Coals to France and Italy decided to add to the list of exporters under the limitation schemes at the discretion of the Local Committees. The Coal Controller has now given his sanction to this recommendation, but refuses to allow firms outside the coal trade to participate in this modification. The Controller has also decided that persons or firms in this country acting as buying agents to coal importers abroad can only be regarded as exporters under the directions if they are completely dissociated financially from their principals and retain for themselves the whole of the exporters' remuneration prescribed by the directions as to the sale of coal. This will prevent firms who have their own salaried buying agents on this side from obtaining their supplies at a lower price than those members dealing through accredited exporters. It is also announced that licences granted for shipment during the quarter ended June is vastly in excess of the allocated quantities and in these circumstances Local Committees have been instructed to refrain from recommending any further applications. The new directions under which prices for allied countries have been changed from a fixed schedule to a minimum scale came into operation on Monday last. Inquiries exceeded available supplies and prices varied considerably and depended upon the individual position of collieries. Some pits were awkwardly placed on account of a scarcity of wagons and, of course, were ready to accept slightly lower figures than those more comfortably situated. In other cases collieries were fully stemmed and refuse to give quotations for shipment ahead. Generally salesmen asked a premium of 10*s.* on the minimum scale, which makes best Cardiff large coals 50*s.* a ton, ordinary large 47*s.*, ordinary drys 45*s.* 6*d.*, and washed nuts 47*s.* On this basis smalls ranged from 35*s.* to 38*s.* 6*d.* according to quality. In isolated cases the premium of 10*s.* was exceeded by as much as 2*s.* 6*d.*, and in other instances buyers were able to obtain small parcels at round 7*s.* 6*d.* above the scale. The demand for Spain is good, but the difficulty of securing releases kept business within narrow limits. Generally, salesmen were ready to take a premium of 5*s.* over the schedule B prices, which brought best Cardiff coals up to 55*s.*, ordinaries 51*s.*, and washed nuts to 50*s.*

Newport.—Monmouthshire coals, both large and small, were in active request, and available supplies were not nearly sufficient to meet the requirements of buyers. Prices were firm but irregular, and dependent upon the individual position of collieries. For allied countries, good Monmouthshire large coals ranged from 45*s.* to 50*s.*, and smalls from 35*s.* to 40*s.*, with No. 2 Rhondda through around 40*s.* 6*d.* For Spain, 5*s.* above the B schedule is usually demanded, and a small business has been transacted at these prices.

Tin Plate Workers' New Demands.—At the annual meeting of the Welsh Tin Plate Industrial Council the tin-plate employees put in no less than 134 claims for increases in wages and improved working conditions. The more important of these applications include a 6-hours' shift for millmen and those engaged in the finishing department, a minimum wage of 5*l.* for head picklers, and 3*l.* 3*s.* for helpers, while annealers at present receiving 13*s.* 6*d.* per hundred boxes claim 24*s.* to 36*s.* with other adjustments.

NOTICES OF MEETINGS.

THE MINING INSTITUTE OF SCOTLAND.—Saturday, June 7, at 3 p.m., a General Meeting will be held in the Heriot Watt College, Chambers-street, Edinburgh. The following papers will be open for discussion: Professor F. W. Hardwick's paper on "The Training of Students in Coal-Mining, with Special Reference to the Scheme of the Engineering Training Organisation"; Mr. David Penman's paper on "A Digest of the First Report of the Mines Rescue Committee"; Mr. P. A. Mossay's paper on "Cooling of Electric Motors, with Special Reference to Totally-Enclosed Motors"; Mr. James Cooper's paper on "The Electric Head Lamp."

THE PHYSICAL SOCIETY OF LONDON.—Friday, June 13, at 5 p.m., a Special General Meeting of the Society will be held at the Imperial College of Science and Technology, Imperial Institute-road, South Kensington, S.W. Agenda: (1) To decide whether evening meetings and afternoon meetings shall be held alternatively in future; (2) To decide upon the proposals made by the Institute of Physics and considered by the Council of the Physical Society as one of the participating societies. After the conclusion of the Special General Meeting, a Scientific Meeting will be held at which the following papers will be read: (1) "A Comparison of the Wave-form of the Telephone Current Produced by a Thermal Detector and a Rectifier in the Heterodyne Reception," by B. van der Pol, Junr.; (2) "The Magnetic Properties of Varieties of Magnetite," by Mr. E. Wilson and Mr. E. F. Herroun.

OPENING CREDITS ON BEHALF OF ENEMIES.—The Board of Trade have issued a General Licence under the Trading with the Enemy Proclamations, authorising persons in the United Kingdom to open credits on behalf of persons or bodies of persons in enemy countries for the purpose of financing transactions that have been authorised under the Trading with the Enemy legislation in the United Kingdom or any other part of His Majesty's Dominions, and transactions between persons residing or carrying on business outside His Majesty's Dominions which have been authorised by the allied and associated Governments or any of them.

IMPORT RELAXATIONS AND RESTRICTIONS.—The concluding meeting of the Consultative Council on Imports was held at the Board of Trade on Monday, the 2nd inst. In view of the completion of the council's work *The Board of Trade Journal* of yesterday has issued a Consolidated List up to date of the import relaxations and existing restrictions. The list is divided into two parts: (1) The articles which may be imported without licence from the Department of Import Restrictions, and (2) the articles which may not be imported without licences.

BRITISH SCIENTIFIC PRODUCTS EXHIBITION, 1919.—On account of the very large number of applications that have been received by the Organising Committee of the forthcoming Exhibition of British Scientific Products, all the space available at the Central Hall, Westminster, has now been allotted, and no further applications can be considered. The exhibition will be open to the public from July 3 to August 5, 1919. Its scope will be more extensive than was possible at last year's display, when war conditions made it necessary to withhold from public view much of the scientific and technical work carried on in Great Britain. Striking testimony will be furnished of the enterprise of British manufacturers, and the uses they have made of science and invention in new industries and the development of old.

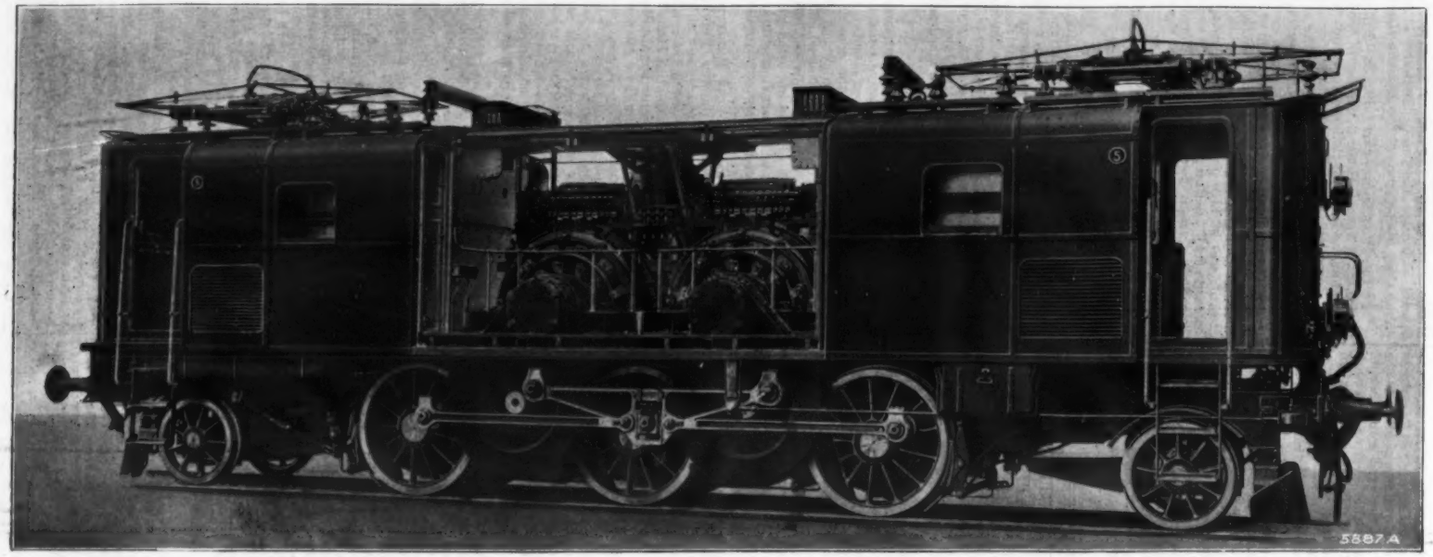
MELBOURNE SUBURBAN RAILWAYS ELECTRIFICATION.—An electric service on the Sandringham–Essenden section of the Melbourne Suburban Railways was publicly inaugurated on May 28 by the Hon. W. A. Watt, Acting Prime Minister of the Commonwealth; the Prime Minister of Victoria; and the Minister of Railways. This first section is 20 miles in length, but the whole system of railways being electrified include some 150 route miles. It will be remembered that German manufacturers made a great effort to have the single-phase system adopted, but when it came to a comparison based upon actual tenders, the 1,500-volt direct-current system, which was ultimately chosen, proved much the cheaper both in first cost and in operation. The work began in 1913, and has been carried out for the Victorian Railways Commissioners under the supervision of Messrs. Merz and McLellan, consulting engineers, Westminster.

THE LATE MR. HUGH CALLAWAY.—We regret to have to announce the death, which occurred on May 31, of Mr. Hugh Callaway, of Messrs. J. I. Thornycroft and Co., Woolston, Southampton. Mr. Callaway was born on November 30, 1864; he served an apprenticeship of five years, from February, 1882, to February, 1887, with Messrs. Denny and Co., Dumbarton, and remained with them for a further period of nearly two years, until November, 1888, as draughtsman. He then served as fifth and fourth engineer, from November, 1888, to November, 1889, on the R.M.S. Tainui on the New Zealand trade. He was later, down to February, 1891, works manager to Messrs. Massey and Co., general engineers and ironfounders, Madras, then he secured the appointment as deputy-superintending engineer to the India General Steam Navigation Company, Calcutta. Between April and November, 1891, Mr. Callaway had entire charge of their engineering department, during the absence of the superintending engineer. On September 1, 1892, he was appointed superintending engineer to the said company. He was a member of the Institution of Civil Engineers since 1900, and from 1895 a member of the Institution of Naval Architects.

15,000-VOLT SINGLE-PHASE ELECTRIC LOCOMOTIVES FOR THE SWISS GOVERNMENT RAILWAYS.

CONSTRUCTED BY LES ATELIERS DE CONSTRUCTION OERLIKON, ENGINEERS, OERLIKON, SWITZERLAND.

(*For Description, see Page* 727.)



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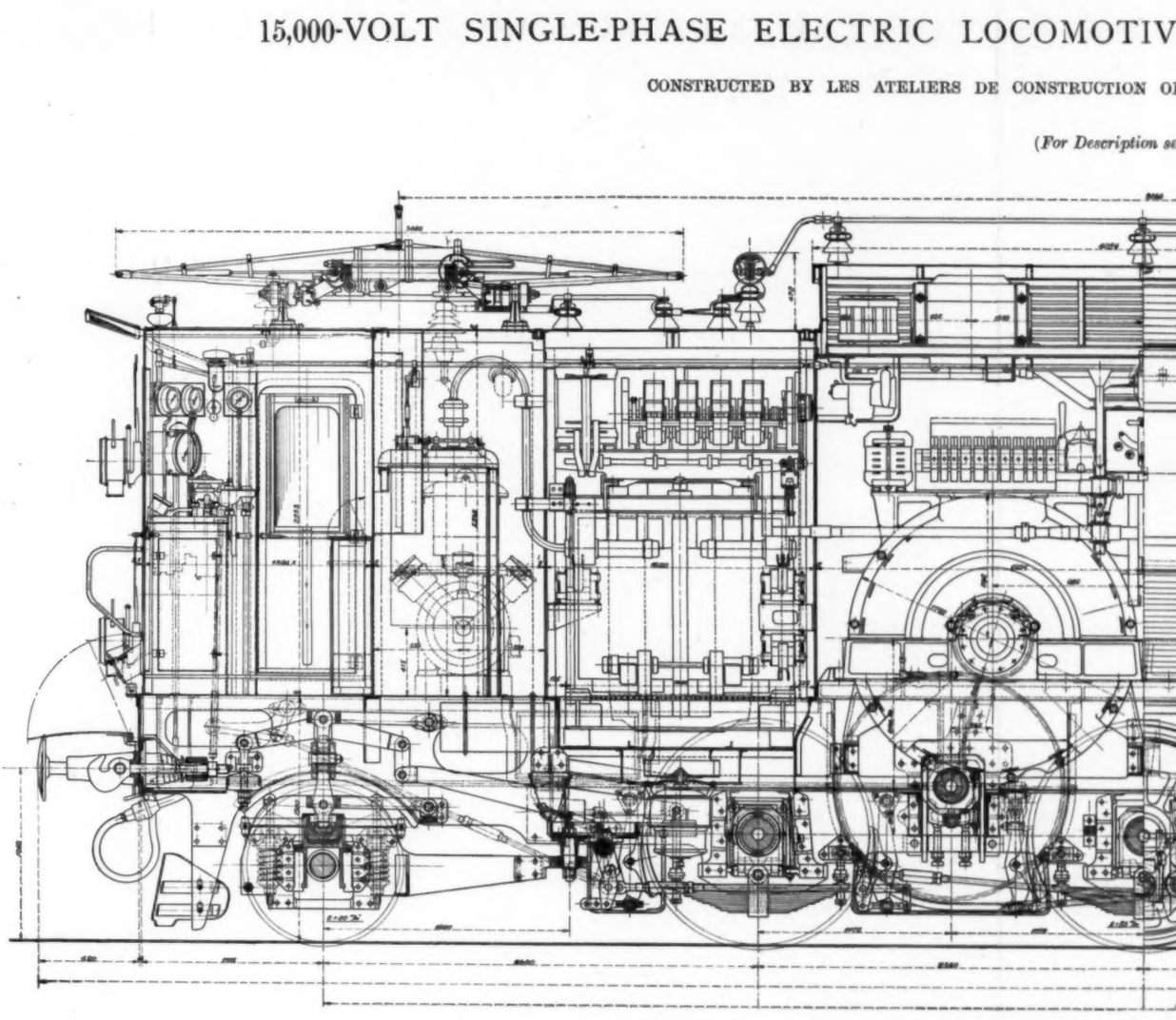

FIG. 1.

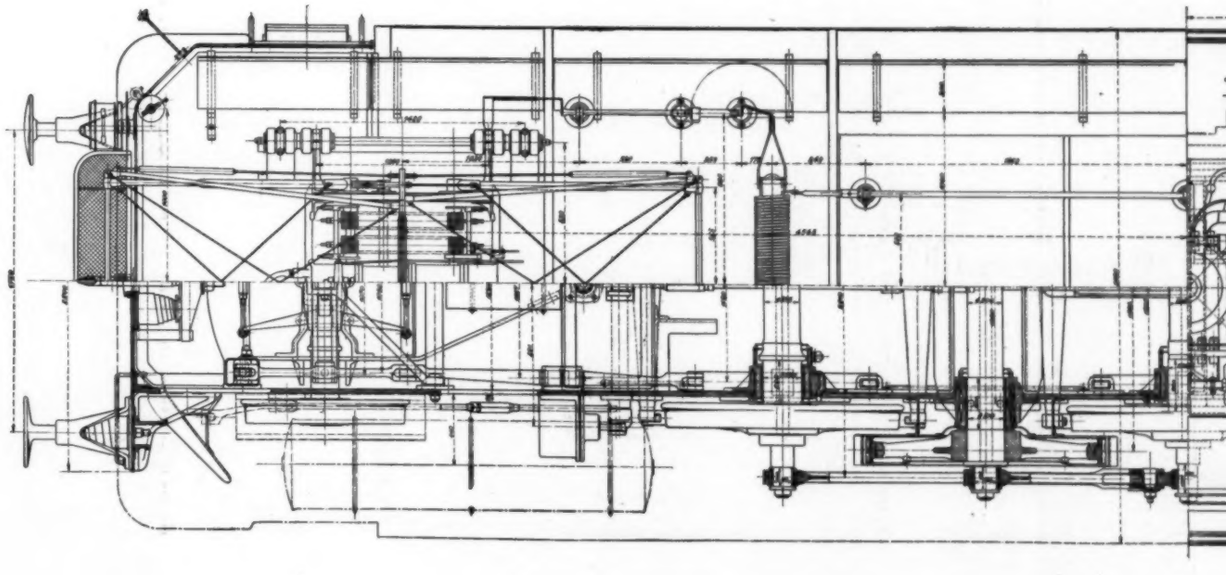

FIG. 2.

SINGLE-PHASE ELECTRIC LOCOMOTIVE

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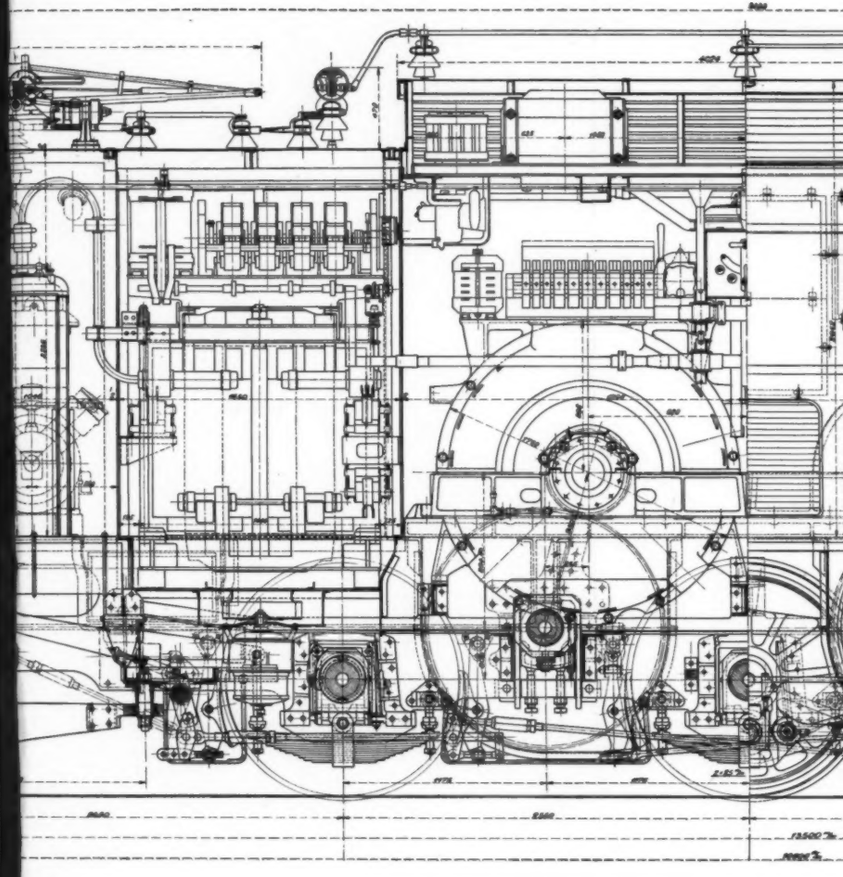

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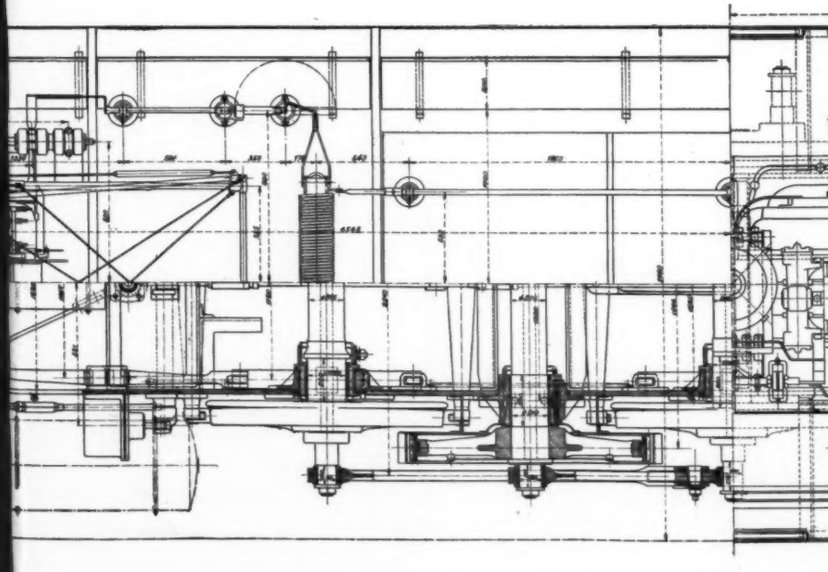
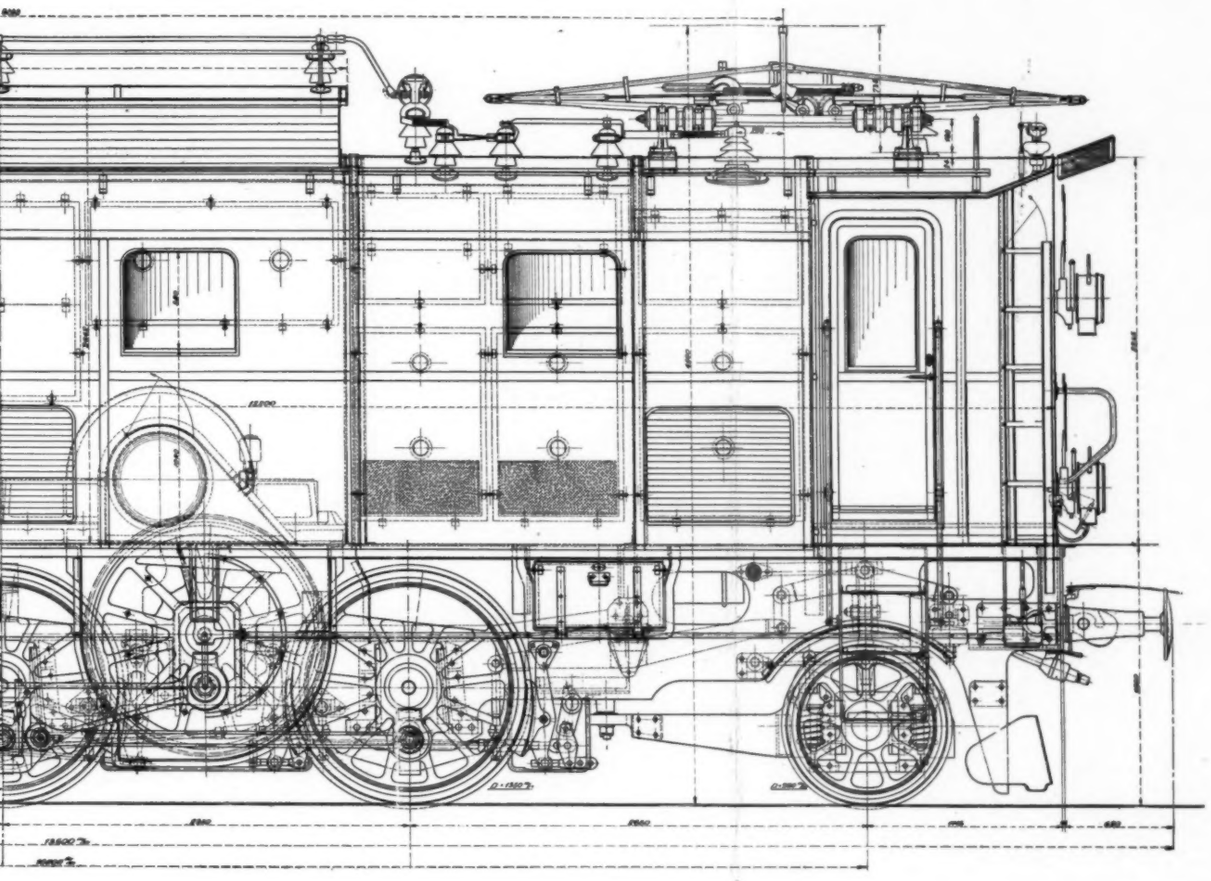


FIG. 2.

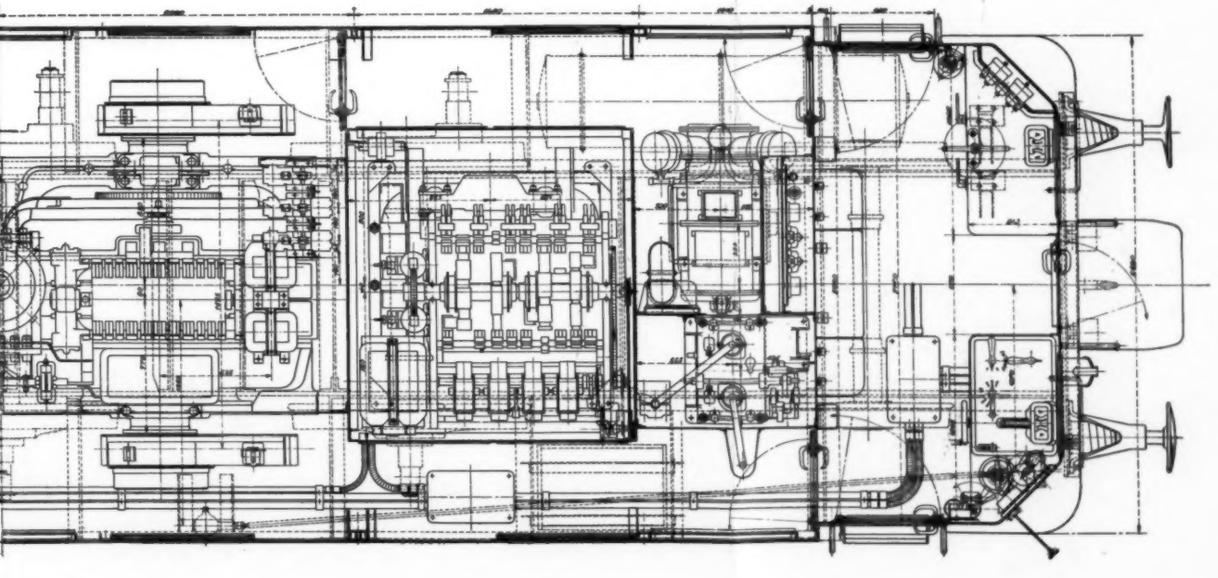
IVE FOR THE SWISS GOVERNMENT RAILWAYS.

OERLIKON, ENGINEERS, OERLIKON, SWITZERLAND.

on see Page 727.)



G. 1.



G. 2.

AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Turner and Henderson, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.
BELGIUM, Brussels: E. F. Satchell, 85, Rue du Tabellion.
CANADA, Toronto, Ont.: Wm. Dawson and Sons, Manning Chambers. Montreal: Sells, Limited, 302, Shaughnessy Building, McGill-street.
EDINBURGH: John Menzies and Co., 12, Hanover-street.
FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque. For Advertisements, Agence Havas, 8, Place de la Bourse.
GLASGOW: William Love.
INDIA, Calcutta: Thacker, Spink and Co. Bombay: Thacker and Co., Limited.
ITALY: U. Hoepli, Milan, and any post-office.
LIVERPOOL: Mrs. Taylor, Landing Stages.
MANCHESTER: John Heywood, 143, Deansgate.
NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland and Christchurch.
NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.
ROTTERDAM: H. A. Kramer and Son,
SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Cape Town: Wm. Dawson and Sons, 31, Long-street.
TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston: Hobart.
UNITED STATES: For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue.
For Advertisements, J. S. Allan, 18, Broadway, New York.

ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication, and certainly not later than Monday morning.

SUBSCRIPTIONS, HOME AND FOREIGN.

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NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 739.

ENGINEERING.

FRIDAY, JUNE 6, 1919.

THE ELECTRIC FURNACE PROBLEM.

THE general discussion on electric furnaces recently held jointly by the Iron and Steel Institute and the Institution of Electrical Engineers promised a valuable ventilation of opinion regarding the position and uses of such furnaces. That it fell far short of its promise could not be attributed to the writers of the papers, for these had been carefully prepared, and contained excellent matter well arranged, and included also authenticated information from an unbiassed source on actual performances of British furnaces during the war. The discussion did not do the papers justice; in fact, few of the speakers seemed to have read the papers, for they were hardly referred to at all, and it seems a pity that the papers were not in the hands of members at least a fortnight before the meeting. It is only in this way that mature and considered opinions can be evoked. Generally, however, the prevailing impression was that electric furnaces were troublesome, that they were expensive, and that they stand little chance in the open market of competing with other methods of steel manufacture. Such an impression going the rounds as the expert judgment on electric furnaces is a serious matter for "electric" steel and is still more unfortunate for a recently developed industry if it be ill-founded. The matter is thus one that demands full consideration.

The application of electricity to steel melting involves no new principles—the steel is made in the same way and the electricity is only the source of heat, and since few electrical engineers know anything about metallurgy and *vice-versa*, a new process which demands a knowledge of both, found difficulty during the early stages in getting the right men to control it. And there have been many cases where the furnaces have been condemned because an electrical engineer was put in charge and ordered to make steel, or a steel maker was given control who had never seen an amperemeter before and could not be brought to realise that it had anything to do with his steel. And even yet some metallurgists do not realise that it is just as easy to make bad steel in an electric furnace as it is in any other type of furnace.

The paper contributed by Mr. Mercer, entitled "Electric Furnaces in the United Kingdom, 1918," records widely differing results. The energy consumption per ton varies from 650 to 5,250 units and apparently the size of the furnace does not exert a very great influence since there are ½-ton furnaces using 750 and 7-ton furnaces using 1,035 units. The consumption of electrodes varies from 16 lbs. to 130 lbs. for amorphous carbon and from 6·5 lbs. to 47 lbs. for graphite. The output shows equally large variations, although these cannot be compared so easily. Special mention should be made of one 12-ton furnace which turned out 1,010 tons of steel in one month, or on an average one charge every six hours. These results can only lead to the conclusion that skilled attention counts far more in electric furnace work than almost any other factor, and that this fact is far from being universally appreciated.

There has been real trouble naturally, which can be grouped under the following headings:—(1) Design of furnace. (2) Design of electrical gear. (3) Refractories. (4) Electrode trouble. Trouble in design was mainly the result of constructing furnaces which were too light to stand the admittedly severe conditions in steel works, and it naturally took some years to find out the weak points and to design the special details which avoid delays due to mechanical trouble, and which can be easily inspected and repaired. Most of these faults lay in the electrode gearing and in the tilting arrangements and gave rise in the first case to breakages of electrodes and short circuits, and in the second case to serious delays. The stripping of the leading screw in the tilting gear has been known to lead to the upsetting of the furnace which scattered its molten charge all over the stage.

Electrical trouble arose mainly in the transformers, and switch gear through overloading. The manufacturers were soon able to overcome this, however, and so to strengthen the transformers, especially on the low tension side, that they were able to withstand the heavy surges which are inseparable from electric furnace working. At the present time all the makers have learnt their lesson, and there should be no failure on the electrical side. It will always pay to put in ample transformer capacity because although the first cost may be greater, the running costs will not be appreciably affected, and the chance of breakdown is infinitely less.

It is pleasant to recall that the refractory problem has been very materially solved during the war period, and that all classes of British bricks have improved to a surprising degree. British magnesite can now be obtained equal to the Continental brick in every respect, so that in competition this factor need no longer be an excuse for lagging behind. Electric furnaces, however, are severe even on the best brick, but this is largely a question of furnace design. Any degree of overhang in the walls is absolutely fatal to long service, and the bottom should be brought well up the side walls to protect them from the slag. There is room still for considerable improvement in the application of refractories to electric furnaces.

The electrodes are either graphite or amorphous carbon, and while the former gives no trouble it is very expensive, and although the latter is cheaper it gives endless trouble through cracking and bad joints. There is no more heartbreaking thing than a bad batch of electrodes which fall off into the bath in large lumps and delay, if they do not completely spoil, the charge of steel. It remains to be seen whether the manufacturers can improve the uniformity of their product, because unless this is done they will not stand in competition with graphite, which although of higher first cost is often the cheaper in the end. There is room for the development of British enterprise in graphite electrode manufacture, though we understand that at least one firm is actively engaged in this direction. So far only the direct arc type of furnace has survived the searching test of works practice—the induction furnace so delightful to contemplate in theory is apparently moribund if not already dead. Although many patents have been taken out for special electrical connections, and arrangements for direct arcs we must say that the differences are mainly between "tweedledum and tweedledee," and that the manner of application of electric heat is of the very least importance compared with the mechanical design of the furnace.

So far we have practically stressed the bad features of the electric furnace, but turning now to the success there can be no doubt that as the return of Mr. Mercer shows, the electric furnace can with proper supervision turn out a large output of high quality steel of any composition. An example of what can be produced under proper conditions was brought out by Colonel D. Carnegie, who referred to a shop with ten 6-ton furnaces started for war purposes in Canada which produced more than 400 tons per day of special steel. This output means a steady rate of seven charges per 24 hours, or an average duration of 3½ hours for each charge—a truly marvellous performance. Its special function lies in the manufacture of high grade alloy steels and high grade castings. Metallurgically it is an undoubted success, but this will not extend its use in the slightest if it cannot produce at a cost which will enable the market price of its specialties to yield a profit. The chief items of cost in electric steel are the labour cost, the cost of current, the cost of electrodes and the cost of scrap. The labour cost is high in the present state of development since the furnaces are all of small size, and the same number of skilled men running a 3-ton furnace could run a 20-ton furnace with one or two additional labourers. For these small sizes, the only competitive process is the crucible process, and here there is no comparison because the electric furnace can turn out steel at so very

much lower a cost that it was already displacing the crucible process rapidly in pre-War days. For large furnaces the labour cost compared with open hearth plant should be less since a larger output is obtained for equal charging capacity.

The cost of electrodes is an important item amounting at the very lowest to about 8*s.* per ton at present prices, but this can be reduced materially as the majority of the graphite electrodes are imported, and there is no reason why this item should exceed one-half that just named or even less.

The cost of current used is one of the main charges, for even assuming a low average figure of 800 units per ton at 0·8*d.* per unit it amounts to 53*s.* 4*d.*, which is about six times the fuel cost in open hearth practice at the present day. Nor is there much chance of getting this greatly reduced if power is taken from an ordinary supply company, the very low load factor—amounting to about 20 per cent. for one furnace—militates against a cheap rate unless there is a bank of furnaces running together. With several furnaces running together the variations in power can be greatly minimised and a very good load factor obtained, but this requires a minimum of about eight furnaces to wash out the peaks, and shops with this number are few and far between. To compete with open hearth work the cost of electricity would require to be in the neighbourhood of 0·2*d.* per unit though this is a rough estimate made without taking into account all the factors in detail. This certainly rules the electric furnace out as a produce of cheap classes of steel and confines its field to the production of special alloy steels which cannot be made so successfully by other processes or in the production of steel castings where sound steel is essential. Whether it is ever adopted in the cheaper steel trade depends more on the power engineer than the metallurgist.

The only other question is that of scrap and, since electric furnaces only use scrap without pig-iron, it is a vital one. Although at the present time there is a shortage of scrap, how long is this likely to continue? There will always be in the future a production of all classes of scrap which will be competed for by steel works, and those works which will produce steel cheapest will be those using liquid pig, a process with a limited consumption of scrap. Other works using cold charging will have difficulty in bringing their costs down to the level of the direct process works, and so a few shillings on the cost of the available scrap will be a matter of some consideration to them. They will also naturally prefer the heavy scrap, and turnings and light scrap will be their last resource. It is just these qualities of scrap which are most suitable for electric furnaces, and since they are making a higher priced steel it would seem that they will always be able to procure all the light scrap available in the open market. And since most of the engineering works produce scrap of this description there should be no difficulty once trade is normal in supplying electric furnaces with sufficient scrap for their requirements.

The general increase in costs has been during the war more or less constant for all sections of expenditure in steel works, and so relatively steel making processes are much the same as they were in pre-War times. And prior to 1914 "electric" steel was making rapid headway in yearly production in the United States, Germany, France and other countries. If it could compete successfully then with other processes there is no reason why it should not still compete successfully, and indeed this much seems certain, that for all special steels and castings it will not be long before the electric furnace is the only process in use for this class of products.

HUMAN EFFICIENCY.

EFFICIENCY is the relation existing between the total units of expended energy and the amount turned into useful work. The competent man achieves in a given time a greater total of useful work than the inefficient. The energy expended by each in a working day does not differ very materially, but the effect of their application does, and herein lies the divergence. It is training and skill which increase the ratio of the useful to the total. In a highly-trained individual there is neither fumbling nor waste effort, every movement counts. He sifts the actions which matter from those which are wasted, and thereby spares himself useless effort.

It is a rather curious reflection that the pursuits in which the greatest percentage of human energy is transformed into useful effort are those in which the effort is entirely wasted, and the resultant has no commercial value. In sport and in organised games the individual who excels has so disciplined his muscle and brain that the effect is obtained with the least expenditure of energy. The pleasure felt in the pursuit of his own inclination is a valuable factor in his efficiency. For this reason a man is most useful where his choice and interest coincide with his work. Most men worth their salt resent useless effort. Avoidance of superfluous effort has been one main factor in the evolution of mechanical art. Not so much necessity, as an inherent disinclination to toil, has led to a large mass of invention.

It was, for example, the disinclination to undue effort which produced the first steam-engine valve motion in the days of Watt. While inventors are not primarily philanthropists, and their greater representatives have been the incarnation of restless activity, still the incentive was as much reduction of drudgery as the possibility of reward and the extension of knowledge.

Three main aims underlie the substitution of mechanical art for the drudgery of muscular toil. First the saving of effort, and the easy attainment of what otherwise would be laborious. Second, an increase in speed. Third, the obtainment of things otherwise impossible or commercially untenable. In the pursuit of the greatest result for the least expenditure of human energy, the machine is everywhere replacing simple muscular effort. Skilled handicraft will never be superseded, but there is little reason for the retention of more sordid toil. The increase of human efficiency by the avoidance of undue effort is becoming more and more a feature of modern machine design. Handiness is a leading characteristic of present day tools, all the controls being grouped within easy reach. Having revised all conceptions as to the use of labour in other men's businesses, the engineer is appreciating the refinement of such methods in his own.

The total units of human energy available in any period of time are a limited quantity, and it is a paramount duty to avoid their wastage. No man wishes to exhaust all his daily store of energy for his daily task. He expects and needs to reserve a proportion for his own consumption; as a rational being his production of energy is shared between his employer and himself. Where shop conditions are adverse, because of poor equipment, the working day, although of the same duration, is, for this reason, longer than where more rational conditions obtain. This is the same thing as saying increased production depends upon better conditions. Modern mechanical appliances have advantages both for master and man. To the former they represent increased output, to the latter they mean an easier day's work with a greater amount of energy reserved for his own uses. It is simply that the ratio between useful and total effort is altered to give greater efficiency and benefit to both. A quotation from a recent article by Lord Leverhulme is worth reproduction: "Man is not a machine. He is the master of machines, and by inventing better machines and bringing more machines under his dominion for production purposes, he will be able to create a bigger fund of wealth out of which he can take a bigger reward for his services."

We have now come to an era of shorter hours plus higher wages, and while the industrial outlook causes grave anxiety there is no need for wild alarm, for if all parties will accept the new conditions in a new spirit, they need not involve higher productive cost. If properly understood and met they are an incentive to modernise production and they place an added premium upon efficiency. In the daily discussions upon the future of industry the chief factor seems to be disregarded. This is the fact that, of all men, the engineer holds the key to the apparently insoluble problem. He has always been rather timid in pressing his claims and his opportunity has been restricted in that he has not been encouraged to apply fully those labour-saving devices which use human energy economically. Just as modern wealth is largely his creation, so future prosperity is contingent upon his activities. Under the spur of national necessity, unhampered by considerations of cost, the engineer has accomplished productive marvels. Under the provocation of resurgent labour industry can only be stabilised by the application of the same ingenuity to its problems. The present incentive is nearly as powerful as national necessity, and granted the power to apply mechanism and management in unstinted measure, the future can be made secure. If labour is ensured against want, poverty and dispossession, it should not be reluctant to allow the more intensive methods whereby the wealth it requires can be created. Shorter hours, increased wages, better conditions can all be afforded, but only by the combination of real effort coupled to the fullest extension of mechanism. The hope of the future is the engineer. Individual prosperity, as well as national solvency, lie in the co-operation of the engineer with the scientist, and without new invention or radical departure, but by universal and intensive application of the known and proven, vast strides in the power of wealth creation can be made. Priority must be given to necessity and luxury must be penalised. It is clearly useless to attempt to solve industrial trouble with the idea of individual aggrandisement; labour is not interested in the creation of profits in which it has no share.

INTERNAL-COMBUSTION ENGINES AND PISTON RINGS.

IT is generally admitted that success with internal-combustion engines can only fully be achieved by adopting the most careful design and construction of certain of the vital units of this type of engine. A full knowledge and an ample experience with other prime movers helps but little towards a clear appreciation of what are these crucial details with internal-combustion engines. These notes are drafted with a view to indicating the importance of the part played by the piston ring in the performance of internal-combustion engines of all types.

It cannot but be remarked that the mechanical efficiency or the ratio between brake and indicated horse-power with internal-combustion engines is relatively low in comparison with steam engines. A figure in excess of 80 per cent. is rarely achieved, and is only reached with relatively large and slow-speed engines, working on the four-stroke cycle, and with few, if any, auxiliaries, such as cooling water, forced lubrication pumps, &c., driven directly from the engine. Naturally, this loss of over 20 per cent. of the indicated horse-power has been fully investigated, with the result that half at least is found to be directly attributable to piston and piston-ring friction. This definite absorption of power some 10 per cent. of the indicated and 12 per cent. of the brake-horse power of the engine can be said to depend primarily on the following factors: (*a*) The quality of the metal of the piston rings, piston and liner; (*b*) the fit and condition of the piston rings; (*c*) the quality of the lubrication (certain tests which have been carried out go to prove that, up to a certain point, a diminution in viscosity of the lubricating oil increases the mechanical efficiency, and in one case the efficiency was increased by water injection into the combustion chamber); (*d*) the amount of the clearance between the piston and the cylinder walls has an influence on efficiency; (*e*) the mean effective pressure, the compression pressure, and the pressure between the piston, the piston rings and the liner can probably have most suitable values for the reduction of this friction loss to a minimum; (*f*) the temperature at which the engine runs will have an effect upon the lubrication and on the piston clearance; and it has been substantially proved that there is, for a given engine, a temperature giving maximum mechanical efficiency.

From the foregoing it will be seen what a large part is played by the design, the material and the workmanship of the piston rings. The conditions under which the piston rings in internal-combustion engines are called upon to play their part are extremely severe. It is probable that in regard to temperature the piston ring is at as high a temperature as any part of the engine, excepting perhaps

the piston crown, where this part is not cooled by either water or oil. Heat will be generated by the rubbing contact of the piston rings with the cylinder walls. The piston ring is not only pressed against the cylinder walls by the pressure consequent upon its own spring, but is pressed out also by the pressure of gas behind the ring in the piston groove. Sufficient rings must be provided in each piston to achieve the requisite degree of gas tightness under all running conditions, and contingencies such as rings gumming up with carbon, or breaking, must not be lost sight of. An excessive number of piston rings increases needlessly the total engine friction, a point which will be returned to later. Of the heat generated by the combustion within the combustion chamber, a substantial amount is transferred from the piston crowns (when uncooled by water or oil, and the great majority of internal-combustion pistons are so uncooled) to the water jacket through the metal of the piston to the piston rings, and so to the cylinder and the cooling water in the cylinder jacket. The heat transfer through the piston rings is therefore an important function of the internal-combustion engine. The subject of "growth" of cast-iron has lately received much attention in connection with pistons and cylinder liners, but the piston ring, especially the top ring or rings of the piston, have not received sufficient attention as probably being subject to more intense heat conditions than most of the other parts of our internal-combustion engine.

In regard to design, piston rings should have the exact section to give the desired pressure against the cylinder walls. The butt should be such as to prevent jamming when the expansion at full working temperature takes place, and yet should reduce to a minimum the possibility of gas leakages. Even pressure all round the circumference is an important item which can only be achieved in practice by casting the piston rings so that internal casting stresses are minimised, and then after machining, hammering the ring to ensure the exact spring, to give even pressure all round the circumference.

Compression is one of the essentials to efficiency in internal-combustion engineering. A certain percentage of leakage past the piston rings is inevitable. This leakage is most detrimental. Firstly, to efficiency, since work has been put upon the charge within the engine cylinder to compress it to the pressure of leakage, and if the rings leak during the compression stroke, this work is entirely lost. A leakage of compressed gas during the compression stroke means further that there is less air trapped within the combustion space to support the combustion of the fuel, or with gas and petrol engines there is less mixture to burn. The power which the engine is capable of developing therefore falls off, and so the efficiency diminishes. With the majority of internal-combustion engines, a reduction in compression pressure apart from quantity of gas compressed means a decrease in efficiency of the cycle, and so an increased fuel consumption per unit of power output. If the rings leak during the firing, stroke work is lost and the consumption of fuel is increased. With leaky piston rings, of course, loss of gas will occur both during the compression and the firing strokes, but mostly probably during the firing stroke. Secondly, there is an intensely practical side to this question of piston-ring leakage. Hot gases escaping past the piston rings, burn up the lubricating oil film on the working surface of the cylinder and tend thus to cause the piston to become unduly hot through the increased friction arising from this lack of lubrication. The hot gases blowing past the piston heat it directly, and so tend towards seizure. Further, the working conditions of the top end or gudgeon-pin bearing are rendered less satisfactory. Distortion of the piston is a probable result, and the causes enumerated can readily, singly or collectively, have the effect of causing a seized piston, with the possibility of all the attendant consequences of scored or cracked liner or cylinder, damaged connecting rod, &c.

The quality of the metal of which the piston rings are constructed, is therefore a matter of prime importance, no less than in the case of the cylinders, liners and pistons. Steel for piston rings has been repeatedly tried, but without success. Cast-iron is cheap and has peculiar properties of taking on, in use, an excellent surface for resisting wear under conditions of rubbing contact, whilst giving the requisite degree of spring. There are few metals, however, which can vary so much in practice as cast-iron. The iron for piston rings should have a reasonably good tensile and high shock-resisting figures, should resist growth due to temperature, and have good wearing properties. The casting must be without flaws. A centrifugal process for casting piston rings has been developed, which gives a quality of structure of metal, tests, and running results, greatly superior to any metal produced by sand or ordinary methods, and we hope to give later full particulars of this process and the products therefrom.

NOTES.

The Restoration of Pre-War Practices.

When in the early part of 1915 an agreement was come to between the Government and various trade unions for the suspension of trade practices which might interfere with the output of munitions, it was clearly understood that the suspension should cease to be operative after the war. The rescinding of the suspension has also been promised to the unions by the Government, in very definite terms, on more than one occasion since then. The Bill for the restoration of pre-war practices which passed second reading in the House of Commons on Monday, thus represents the meeting of a debt of honour and unquestionably the Bill will pass all its stages in due course. We would wish nothing else, and yet it is to be hoped the Bill will not prove a mere sterilising influence leading back to many things which, once having left, we would do well to leave for ever. The pre-war practices which were dropped in a national emergency were concerned essentially with artificial restriction of output, and the forbidding of the employment of unskilled labour on processes which, according to trade union definition, were "skilled," but which unskilled people during the war have shown themselves quite able to carry out. Maximum production per employee, which in the end is the cheapest production, is wanted just as much now as in 1915, and if an unskilled man can do a job it is waste of national resources for a skilled man to do it. One can easily understand and sympathise with the workman's point of view of 1914, that if he worked too hard he would simply put his mate out of a job; but one hopes that a wider and truer appreciation of economic laws is making some headway among our skilled workmen. The remarks of Mr. Clynes in the House of Commons on Monday were of good augury in this connection. Further it is in no way to the good of the Amalgamated Society of Engineers that they should insist that a job which can, and has been, quite well carried out by a servant girl after a month's training should be confined to a fully qualified journeyman. To do so is really to depreciate the value of the journeyman. The skilled man has in some ways been badly treated during the war, especially in connection with the relation between his wages and those paid for quite unskilled work—after all it was the skilled man who made the guns and shells, or who taught other people how to do it—none the less his true policy now in the interests both of the nation and himself lies very far from an insistence on the restoration of the conditions of 1914. If wisely handled this Bill may become the skilled man's charter in no narrow sense of "restoration." It gives the unions magnificent bargaining power. Let them fully and frankly admit that work which can be satisfactorily done by an unskilled man is no work for a skilled man. In no way can the tradesman more surely take the position which his training and skill entitle him to, and in no way can we more surely build up a newer and a greater industry on the ashes of the war.

Electrolytic Aluminium Rectifiers.

Under the peculiar title "Electric Discharge on the Surface of a Solid Electrolyte. The Theory of Electrolytic Safeties against Overtension," the *Physical Review* of March last, publishes a paper presented by W. Šulejkin to the Moscow Institute of Science in May, 1918. The paper really deals with the behaviour of aluminium anodes in electrolytes, in which they become covered with a film of highly porous oxide or hydroxide and of oxygen. This film being of very high ohmic resistance is able to stop several hundred volts, and is therefore utilised to convert alternating currents into unidirectional currents and, in the lightning arresters —which the journal mentioned calls "safeties"— to prevent the escape of line currents when the temporarily exceptional high tension of lightning discharges or current rushes has broken down the insulation in the gap. The devices fail when the tension exceeds a certain critical value, and it is often asserted that this failure occurs because the insulating film is then broken through and direct communication is set up between the electrolytic and the metallic electrode. That explanation is insufficient, however, because long before, with increasing tension, the volts have reached the critical value, bright spots appear on the anode and gas bubbles are liberated, showing that the discharge has penetrated the oxide film. These perforations of the insulating film are supposed to close up again, as long as the critical volts are not exceeded. According to Sulejkin the importance of the critical volts is of a different character. The equilibrium is, he points out, in the first instance kinetic, not static; secondly, ruptures are constantly formed and closed up again, indeed, but when the critical volts are reached, the discharge assumes the nature of an arc between the anode and the oxide film, which is rapidly destroyed thereby. This arc discharge would then be the characteristic feature, and the point was suggested to Sulejkin by experimenting with wires of aluminium or platinum fused into glass tubes so that only the wire end, less than 1 mm. in length, protruded into the liquid. When the critical tension was attained—which depends on the nature of the electrolyte and its concentration—the glass tube cracked and the colour of the discharge between the electrode and the liquid changed from yellowish into dazzling white. He obtained the same white flash when he dispensed with the sheathing glass tube, but approached a piece of glass (or quartz, enamel, or other solid insulator of this type) to the end of the wire within the liquid. He found that the critical tension did not depend upon the kind of glass, except when the glass was highly charged with metallic oxides; but substitution of a metallic conductor for the insulator prevented arc discharge. The experiments were made with anodes of aluminium and of platinum or nickel and with various electrolytes, caustic soda and sodium carbonate, sulphuric acid and sulphates, hydrochloric acid and chlorides, but not with the alkali phosphates and borates which are frequently used as electrolytes in these rectifiers. The anions which are believed to be chiefly concerned in these phenomena, when there is no insoluble hydroxide film, were thus: OH, HCO_3, SO_4 and Cl. The new experiments may not fully explain the peculiar phenomena of the aluminium electrolytic rectifier, but the influence of the arc discharge at and above the critical tension seems to be a point which had not attracted the particular attention of Günter Schultze, the chief investigator of these phenomena, and of other workers in this field.

The Chemist and Engineer and the Petroleum Industry.

"Life is too short for the chemist to be his own engineer or for the engineer to be his own chemist." We are inclined to concur with this sentence with which Dr. F. Mollwo Perkin, F.I.C., concluded a paper by himself and Mr. T. C. Palmer, A.M.Inst.C.E., read before the Institution of Petroleum Technologists on Tuesday, May 20. We will not quarrel with the authors either as to the question whether the distilling and refining of petroleum and the treatment of the products depend more upon the engineer than upon the chemist. We should simply say that the engineer is indispensable in chemical manufacture and in any works, both with respect to the design and working. Dr. Perkin does not fancy the terms chemical engineer and engineering chemist, and he thinks that an engineer and a chemist will do better than either the chemical engineer or engineering chemist would do alone. That statement brought down upon him censure by Professor J. W. Hinchley, Dr. Ormandy, and Mr.

Aufilogoff. The latter asked who was to decide if the chemist and engineer should disagree; the manager would be incompetent, and an arbiter would have to be called in. In reality the speakers did not differ so very much, however. Dr. Perkin wants his chemist to have a fair knowledge of engineering and his engineer to know some chemistry. The college and courses of chemical engineering which Professor Hinchley and the others advocated, have long been appreciated both on the Continent and over in America, and much of the success of German chemical manufacture was rightly ascribed to the German chemical engineers. There is no doubt that chemical engineering should be taught at technical colleges. But even the new chemical engineering college would hardly turn out a chemical engineer capable of taking charge of oil works. Those works have their own particular problems. Many oil works are badly designed on the whole and in detail; that was generally admitted, and not all the plants which look like superior engineering work well. The engineer and the chemist must collaborate at the various stages, and the competent oil engineer is trained in the oil works and does not owe his efficiency merely to a college diploma. Specialisation at an early stage is to be depreciated; the college should give a sound general foundation, as Sir Boverton Redwood pointed out. Some professors are too anxious to train students for particular industries. That had better be left to the trade schools or cognate institutions and to the works. In Canada the professors of engineering colleges arrange with the manufacturers for holiday work of their students. Such arrangements are more easily made in young countries than in the old-established centres of industry. But it is in the works that the student learns his fitness for a particular branch, and there he should settle on his speciality. Like the paper, the discussion referred to a great many points, the buying of coal on the basis of calorific value, the use of economisers, coal carbonisation, and combustion control, &c. Sir Frederick Black, the President of the Institution, drew attention to the use of pulverised coal, a subject which was last month brought by Mr. L. C. Harvey before the Iron and Steel Institute. The point mentioned by Sir Frederick Black was that in America about 30 per cent. of pulverised coal or coke are mixed with oil or tar and sprayed with the burners; when the mixture was kept in tanks, the coal remained in suspension in the oil for some time; but he had found that a mud deposit settled in ten weeks or so, and that fact made the use of such fuel awkward for marine purposes.

Compressibility at High Pressures.

An extensive series of experiments on the compressibility of metals, quartz and some salts at high pressures has been conducted at the Geophysical Laboratory of the Carnegie Institution, Washington, by L. Adams, E. P. Williamson and J. Johnston (Journal of the American Chemical Society, January, 1919). The test-piece is placed in the cylindrical cavity of a solid steel bomb which is fitted with a piston; the remaining space is filled with an oil which will not thicken at high pressures, kerosene being selected. The piston is forced down by hydrostatic pressure, and simultaneous readings are taken of the piston displacement and of the pressure exerted. From these data the volume change of the contents of the bomb can be deduced, subject to the correction that there are three components of this change: (1) The compression of the specimen; (2) the compression of the liquid; (3) the distortion of the bomb. Components (2) and (3) might be separately determined; it is more convenient to determine them together by experimenting with a standard specimen of known compressibility. The compression of the standard material adopted, a soft Bessemer steel of 0·2 per cent. of carbon, is according to P. W. Bridgman, proportional to the pressure for loads up to 10,000 kg. per square centimetre, and its mean compressibility, at 10 deg. and at 50 deg. C., is 0·583 and $0·601 \times 10^{-6}$ per kilogramme per square centimetre respectively; Grüneisen's figures for the same material being 0·58 and 0·63, the value 0·60 was accepted as average for the experimental temperature of 20 deg. C. The bomb is a cylindrical block, 250 mm. high, 150 mm. diameter, provided with an axial vertical cavity, 17·15 mm. in diameter and 175 mm. deep. The bomb-material is a vanadium-steel (Halcomb's type D) which never becomes very hard, which requires no annealing, and can be subjected to the seasoning process of Bridgman. For this purpose the cavity is filled with glycerin and water (1 : 2), and the piston is forced down until a pressure of 25,000 megabars (1 megabar = 0·987 atmosphere = 1·02 kg. per square centimetre) is developed; the steel yields a little, and a second pressure of 12,000 megabars, slowly applied, raises the elastic limit sufficient to let the steel subsequently resist 15,000 megabars without deformation. In the subsequent tests the pressure was raised to 10,000 megabars. The packing is, as in Bridgman's device, not attached to the plunger; the plunger consists of vanadium steel (type K, quenched at 850 deg. C. and then annealed for an hour at 220 deg.), and over its stem five washers are superposed, each 1·5 mm. thick, one of copper, two of rubber, one of copper, one of soft steel, and finally, at the top, a collar of hard steel. The pressures are determined after Bridgman by measuring the change in the electric resistance of a wire of manganin or of therol, a substance similar to manganin, but of higher thermoelectric force. The piston displacement was read off on a dial micrometer. The specimens were cylinders, turned or ground to size, of about 20 cub. cm. volume, 15·8 mm. in diameter, 102 mm. long; the volume was redetermined after the test by determining the loss of weight in water. The pressure should be purely hydrostatic; a shear may be set up when the specimen consists of an aggregate of crystals. Plotting the pressures as ordinates against the volume changes Adams and his collaborators found that the curves were sensibly linear for gold, copper, brass, silver, aluminium, steel and calcite; the compressibilities of zinc, tin, cadmium, lead, bismuth, tin-bismuth alloy, quartz and rock salt slightly decreased at high pressures. The compressibility of the tin-bismuth alloy (not of brass) could be deduced from those of the constituent metals. We give some of the compressibilities found, all in the unit stated above: Sodium chloride 3·53, quartz (fused) 3·0, bismuth 2·57, quartz crystal 2·31, Sn-Bi 2·22, cadmium 1·7, lead 2·16, tin 1·64, zinc 1·43, calcite 1·39, aluminium 1·32, silver 0·97, brass 0·89, steel 0·6, gold 0·57. There were hardly any comparison data available, but the figures for quartz and for sodium chloride agree with the elastic constants according to W. Voigt.

Personal.—The Russell Oil and Chemical Company, Limited, National Oil Works, Adams-street, Birmingham, state that they have put down a branch establishment at York Works, Short-road, Stratford, London, E.

The Housing Problem.—The Intelligence Division of the Local Government Board issued last month a small pamphlet on "Housing by Public Utility Societies, the Government Proposals," which explains the formation and scope of these societies, and the financial help they can obtain from Government and the Local Authority for promoting housing schemes. It shows how groups of people, whether of workers alone, or of workers acting jointly with employers or groups of other persons, may combine for the purpose of carrying out the building of houses and obtain the financial help referred to. The facilities afforded by the Government in conjunction with the societies in question should go far towards the solving of the present housing problem.

University College and Hospital War Memorial.—A War Memorial scheme for University College, University College Hospital and Medical School, London, has now been settled, and an appeal for a sum of 30,000*l.* is being issued this week to all old students of the college whose addresses are known. The complete scheme, as settled by a representative and influential committee under the patronage of the Earl of Rosebery, Chancellor of the University of London, includes the following features: A War Memorial Album, containing the records of the academic and service careers of the 268 men who have fallen; Memorial Tablets, recording their names; scholarships for the sons and daughters of the fallen; a Great Hall for the use of the college and medical school; the endowment of University College Hall, Ealing. The hon. treasurer is Captain Wedgwood Benn, D.S.O., D.F.C., M.P., who is a Fellow of the College; donations sent to him at University College will be gratefully acknowledged. Members and friends of the college and medical school who have not received copies of the scheme should apply to Captain Benn, at the college.

LITERATURE.

The Theory of Modern Optical Instruments. A Reference Book for Physicists, Manufacturers of Optical Instruments, and for Officers in the Army and Navy. By Dr. Alexander Gleichen. Translated from the German by H. H. Emsley, B.Sc., and W. Swaine, B.Sc. With an Appendix on Rangefinders. London: Published for the Department of Scientific and Industrial Research by H.M. Stationery Office. 1918. [Price 12*s.* 6*d.* net.]

The appearance of this treatise in an English dress is due to the war, or it would be more correct to say that its publication is intended as an antidote, to correct the neglected condition of optical design and manufacture, revealed by the exigencies of the war. Originality and enterprise had alike disappeared. Middlemen who sold optical instruments made in foreign countries were very prominent, and the so-called makers confined themselves generally to assembling parts of instruments, purchased abroad. That is all altered now, a wholesome revival has penetrated the whole industry, and not only is the country independent of all foreign aid, but is prepared to carry the war into those markets that have long been the happy monopoly of German firms. But when the position was less assured, the Standing Committee on Glass and Optical Instruments believed that the needed interest might be aroused by the translation and issue of foreign works, detailing recent improvements in optical science. It was urged, not without reason, that the indifference and disregard which had long paralysed the trade might be removed, if the advances made in Germany and elsewhere were brought prominently under the notice of those interested. Dr. Gleichen's book was selected as one well suited to the purpose contemplated, the selection being determined in some measure by the fact that Messrs. Emsley and Swaine were already engaged in producing a translation. This treatise is perhaps as well adapted as any could be to exhibit the shortcomings and lethargy that had overtaken the trade, but we do not clearly see the necessity for any translation. The able translators, who are connected with the firm of Barr and Stroud, have furnished an appendix dealing with the theory and practice of rangefinders, presented in so masterly and efficient manner, that there can be no doubt but that they could have produced an original work of at least equal merit to that selected for translation, in which more justice would be done to British enterprise, and our recent activity shown in a more favourable light. In any case, we have a right to insist that awakened energy has preceded and not followed the appearance of this book. The latter will not serve as a stimulant, but may have a career of more solid usefulness.

Terminology and nomenclature in optical science are by no means standardised. The translators state that the subject as treated by the photographer, the practical optician and the university student, differs so widely that the different methods can hardly be recognised as belonging to one and the same science. The Standing Committee have experienced the difficulty that a want of uniformity imposes, but they foresaw that any attempt to revise the terminology would not only have caused a serious delay, but "would have raised difficult and far-reaching problems, which could not at the present moment receive the attention they deserve." As a consequence, Dr. Gleichen's text has been closely followed, and any deviations or additional explanations that were thought necessary are indicated in footnotes. The inconsistencies connected with direction of measurements and with some other practices, are therefore left unaltered. Want of uniformity, by this method, receives further sanction and continuity, but the correct way to treat a translated work has undoubtedly been followed. The object was to present to English students the same work and in the same way as it is presented to German students.

Dr. Gleichen has divided his book into two sections—the former discussing by the usual geometrical methods the laws of refraction at spherical surfaces, and the tracing of rays through a co-axial system of lenses. Rays outside the paraxial region with the accompanying aberrations are not treated so fully, but in an eminently practical manner. The

second portion exhibits the application of the optical principles to the construction of instruments, and it is this second portion we imagine, which recommended the work so strongly to the Standing Committee, and had previously attracted the attention of the translators.

Every optical system which brings about an alteration in the path of a bundle of rays may correctly be described as an optical instrument, but only two types have been widely treated in optical works: The telescope, conditioned to give magnified retinal images of distant objects, and microscopes for magnifying near and small objects, have very generally absorbed the attention of students. The necessities of recent times have forced into notice other forms, in which the magnification is not of primary importance, or in which the objects to be viewed are neither very far distant or very near. As examples of wider application may be given the sighting arrangements for artillery, and periscopes, or such instruments as the cystoscope and some forms of ophthalmoscope. These wider applications of the opticians' art have directed more attention to the eye as an optical instrument, and the conditions under which an emmetropic eye at rest will receive sharp retinal images. The theory of optical instruments is therefore appropriately introduced by a very full description of the human eye in its connection with optical instruments. Too frequently writers have contented themselves with discussing the behaviour of rays in an optical system without reference to the mode of perception, or even of noticing that the eye is not strictly a centred system of spherical surfaces. Average results and measurements must be assumed in some particulars, but the author not only gives the data of the "Schematic eye" of Helmholtz, but the more elaborate scheme due to Gullstrand; indeed, the influence of this latter writer is very noticeable throughout.

Two interesting chapters are devoted, respectively, to the general theory of optical instruments and the magnifying glass in combination with an emmetropic unaccommodated eye, in which magnitude and illumination are ably discussed. Such problems as that a luminous surface appears equally bright at all distances, and that the brightness of a surface cannot be increased by using an optical instrument, are stumbling blocks to many who have not followed the general principles of optical science.

These chapters are followed by a full and practical description of the telescope, treated in a somewhat novel manner. Eyepieces, naturally come under discussion and we meet with an improved form of Kellner, for which some practical advantages are claimed. To overcome the lack of sharpness of image, which has often disappointed those who have used this form of eyepiece, Zeiss, it is stated, has devised an arrangement to remove this defect by combining two kinds of glass in the eye-lens, so that as compared with the Kellner eyepiece, there is a great dissimilarity between their relative dispersions, whilst the difference between the refractive indices is very small. Suitable radii, thickness and refractive indices for the lenses as well as the distances between them, are given. Similar data for a modified Ramsden eyepiece are also shown. In the same section, the construction of prisms and of prismatic telescopes is described in great detail, an addition to the ordinary telescope that has increased the convenience of rangefinders and similar apparatus, besides in many cases reducing the size and weight. A wide series of glass elements with reflecting surfaces have been devised, which it is convenient to describe as prisms, though the commonly-received notion of a prism can in some cases be scarcely recognised. Their function may be to make an incident axial ray after passing through the instrument emerge parallel to itself, or they may revert, or invert, the optical image, or alter the paths of the ray. Some of the ingenious applications that Zeiss has made of these prisms seem to be quaint rather than useful, but in many instances the scope and potentialities of an instrument are largely increased.

The panoramic telescope, better known, perhaps, in this country as the "dial sight," furnishes an example of this extended usefulness. The peculiar feature of the instrument consists in affording the means for viewing a large arc of the horizon without rotating the eyepiece to any great extent. The demand for such instruments arose from the improved methods of gun sighting in modern artillery practice, in which it may be necessary to utilise aiming sights situated behind the gun. The necessary apparatus can be provided by using several objectives of different focal lengths, directed to different azimuths, the rays entering the eyepiece after traversing an inverting system and coming to a focus on a common plane. A single eyepiece is used, and the field of view exhibits several images of different sizes corresponding to various portions of the horizon. A neater method for accomplishing the same result, consists in using a single total reflecting right-angled prism as an entrance reflector, capable of rotation. The reflected image will necessarily become inclined as the reflector is rotated, but this drawback can be overcome by introducing into the optical system an erecting prism that rotates at half the angular speed of the entrance reflector. This device is of British origin. It was proposed by Sir H. Grubb, who applied it to surveying instruments. The special application to artillery sights is due to Messrs. Goerz, and it is a humiliating admission to have to make that notwithstanding the priority of invention, established by Sir H. Grubb, yet at the outbreak of war we were unable to equip our artillery without having recourse to German manufacturers. Needless to say, that the position as regards these sights was very critical, and the dangers arising from adopting a mistaken policy very manifest. It is, however, as satisfactory to know that before the end of hostilities, two firms alone were capable of supplying these sights at the rate of 250 per week, and that this delicate piece of optical workmanship possessed a delicacy and perfection, that Germany never exceeded. The requirements of artillery have led to some very neat and successful applications of the prism, and doubtless when the history of optical progress in Germany during the last few years is written, we shall find that the ingenious devices here described have been superseded by new inventions, showing ever-increasing skill and adaptability. The periscope in particular has offered a great field for the exercise of skill and dexterity.

A chapter on Stereoscopy leads naturally to the discussion of rangefinders, a form of instrument in which is introduced the principle of the binocular telescope with greatly increased interocular distance, and in many cases the exactness of measurement depends upon the accuracy of the stereoscopic picture formed from two objectives. A somewhat novel application of the combination of pictures, taken from two different standpoints is provided in the stereo-comparator. In this instance, photographs of portions of the sky are taken at six months' interval, when the observers' position is changed by twice the distance separating the Earth from the Sun. Dr. Gleichen states that stereoscopic images of the Moon have been obtained in this way. We do not understand this suggested application. It seems to be hinted that the method is available for the determination of stellar parallax. This may be doubted, but the instrument has been used successfully for detecting instances of large stellar proper motion.

The application of optical science to surgery is illustrated by two chapters, one on cystoscopes, instruments used for the inspection of the human bladder, and in which the lenses are necessarily limited to less than 5 mm. or 6 mm. in diameter, imposing special conditions on the optical system, and another on ophthalmology. In the latter we meet with instances of good results produced by deforming the spherical surfaces of lenses; the object being to eliminate distortion and the difference in magnification, between the paraxial and oblique bundles. A large future lies before this special method of treatment, which has long been applied with good effect to the large lenses required in astronomical observation. The figuring of the surface by zonal polishing has been employed experimentally, but a centred optical system which produces aplanatic imagery for all zones over a finite aperture can only be obtained by systematic deformation. The curvature of image surface, astigmatism and coma have been much reduced by making use of known deviations from spherical surfaces.

To the appendix, extending and supplementing the information on rangefinders, supplied by Dr. Gleichen, we have already referred. Attention may be directed to this contribution with the greater satisfaction, as in the form designed for use by a single observer, the rangefinder provides a marked instance in which English opticians have no need to fear any comparison with foreign competitors. The general theory, based as it is on parallactic displacement, admits of little or no variation. But the instrumental means by which the principle is made available gives opportunity for the exercise of considerable ingenuity, and in the competent hands of Messrs. Barr and Stroud, convenience of arrangement, permanence of adjustment, and facility in use, have reached their limit. The accuracy attained is very remarkable, and is the more surprising when the smallness of the angle that the instrument maker has at his command is taken into account.

Theory of Structures. By ARTHUR MORLEY, M.Sc., M.I.Mech.E., formerly Professor of Mechanical Engineering in University College, Nottingham. New edition. London: Longmans, Green and Co. [Price 14s. net.]

IT is inevitable that the work of any author of repute should be scanned with the hope of finding something above the average, so that the higher the author's reputation, the more will be expected of him. Professor Morley, in addressing himself to the treatment of the theory of structures, deals with matters which have been expounded by so many authorities, so fully and so well, that the task of producing a book on this subject which shall justify itself, and satisfy expectations, is indeed no light one.

It is not perhaps so generally realised as it might be how old are some of the principles underlying this study. Galileo, about 1638—nearly 300 years ago—discussed the principle of the funicular polygon and resolution of forces, and showed that the resistance of beams of rectangular section to bending, varied as the square of the depth and as the breadth. Hooke, in 1660, discovered the proportionality of stress to strain in elastic bodies. Marriotte, a little later, observed that the neutral axis of a beam passes through its centre of gravity, with compression above and tension below; and Bournouilli, about the year 1700, plotted stress-strain curves for beams. Parent, in 1713, enlarged upon these principles, and showed that there is equality of total stress above and below the neutral axis, and that stress is proportional to distance from the axis. He defined also the catenary curve. These fundamental teachings, the beginning of this study, were reached more than 200 years ago, since which time great strides have been made, as will be understood upon opening Professor Morley's book. The scope of this work is that commonly found in books of the kind, and is limited to the consideration of structures of practical type, and of problems arising in such structures, though with satisfying completeness. The opening chapter deals with the three principal elasticities, and their relation one to the other, treated with clearness. Working stresses are considered somewhat fully, including the effects of impact, fluctuations and range of stress, and cognate matters. Following this we have the principles of statics, bending moments, and shearing forces presented—dealt with largely by graphic methods, and fully explained. Stresses in beams of unusual sections are dealt with at length, shear receiving particular attention. Moving loads, moments and shears in beams, are treated chiefly, but not solely by analytical methods. Deflection and elasticity of beams, including problems in continuity, are analysed at great length, and some alternative graphic methods presented with advantage. Combined bending and direct stress, leading up to the treatment of columns, claims also a large share of attention, bringing the reader well past the middle of the book.

The examination of framed structures, roof trusses and girders chiefly, with the usual problems involved in the determination of the axial stresses, under different methods of loading, fixed or moving, is treated very fully, followed by the detailed study

of some typical framed structures. The elastic deformation of frames, both simple and indeterminate, and of sundry arrangements occurring in practice, is examined at length by various methods. A short chapter is devoted to the members of frames, to riveted connections, and details occurring in building structures, followed by the consideration of plate girders and bridges, the process of design being carried through by application to particular cases. More difficult structures—suspension bridges and metal arches—are treated in a chapter of some length. Suspension spans with three and two-hinged stiffening girders are here examined, and metal arches, three-hinged, two-hinged, and fixed-ended. The last chapter deals with miscellaneous problems in earth pressures, foundations and masonry structures. As an appendix there are sundry useful tables.

The above somewhat catalogic statement will give a fair idea only of the matters included in this work, but is not by itself sufficient to convey a good idea of its qualities.

The treatment of elasticities and working stresses is unusually complete and well stated, a good feature, as so much is involved in a right understanding of these. Moments of inertia of sections (plane areas) are dealt with at considerable length by a variety of methods. Those engaged in design will know the time-consuming nature of these computations in cases of irregular profile, and will appreciate the advantages of ready means of achieving the desired results. Stresses, deflections and elasticity of beams are studied with equal thoroughness.

The examination of columns is carried beyond the point commonly reached in text-books, including the case of excentric load effects, considered with quite unusual completeness.

The effects of lateral loading and of bending couples on stanchions are also closely considered. The treatment of stresses in the bracing of a latticed column appears, however, open to question. The method is that commonly, but not invariably given, and appears to be consistent with such stresses as may be developed in latticing at the moment of collapse, by crippling, of a free-ended strut, at its centre. Stresses in lattices so found may give sections which, when the column is more moderately stressed and flexes to the elastic curve, will result in relative overstress of the diagonals, the margin of safety in lattices and column body being then widely different. Kunz, in a work recently reviewed in these columns, states the case, as it is believed, correctly.

The treatment of moving load stresses in frames calls for no other remark than that it appears to meet the requirements of design. The matter relating to cases statically indeterminate will well repay study—here, again, the thoroughness of the author, which is noticeable throughout the book, may be remarked upon.

The consideration of suspension bridges and arches will be valued by those interested in this class of structure. In this country the engineer is but seldom called upon to deal with them, and usually the subject is but lightly touched upon in works of the kind, the more difficult problems arising with such structures not being examined at any length. Professor Morley, however, gives more than a scant attention to these questions of difficulty. This work is of the greater value in that the cases taken for consideration are cases of difficulty such as occur in actual design, so that it will be found useful not to the student alone, but to the practising engineer. The methods are largely analytical, and for full understanding demand, as to much of the matter, quite a respectable mathematical knowledge. Simpler methods are, however, freely given where available, indeed choice of method may be said to be a special feature of this work, as in troublesome cases, any particular process does not appeal with equal force to all. Commonly, it may be said, any work of calculation is most to be relied upon when developed by that process which is best understood by the worker, so that this choice of method is a distinct advantage.

Demonstrations are, as might be expected, commonly given, or the cases dealt with so well presented that no formal demonstration is needed. Various theorems and criteria, as they are quoted, are, as a rule, referred to their originators, a desirable feature. To have these clearly stated, with due acknowledgment, helps the reader to appreciate the steady growth of knowledge in such matters.

A number of well-chosen examples are worked through, and many exercises given to which the student may apply himself, results being appended by which he can test his work.

As is to be expected from the publishers, the letterpress and mathematical matter is clear and well displayed.

BOOKS RECEIVED.

Cotton. By GEORGE BIGWOOD. London: Constable and Co., Limited.

The Periods of Lateral Vibration of Loaded Shafts. The Rational Derivation of Dunkerley's Empirical Rule for Determining Whirling Speeds. By H. H. JEFFCOTT, B.A., B.A.I. Reprinted from the Proceedings of the Royal Society, A. Vol.

United States Bureau of Mines. Efficiency in the Use of Oil Fuel: A Handbook for Boiler Plant and Locomotive Engineers. By J. M. WADSWORTH. Washington: Government Printing Office.

United States Bureau of Mines. Bulletins. No. 127. *Gold Dredging in the United States.* By CHARLES JANIN. No. 145. *Measuring the Temperature of Gases in Boiler Settings.* By HENRY KREISINGER and J. F. BARKLEY. No. 156. *The Diesel Engine, Its Fuels and Its Uses.* By HERBERT HAAS. Washington: Government Printing Office.

Cours d'Economie Politique professé a l'Ecole Nationale des Ponts et Chausses. Par C. COLSON, Livre Premier. *Théorie générale des Phénomènes Economique.* Livre Deuxieme. *Le Travail et les Questions Ouvrier.* Livre Troisieme. *La Propriété des Capiteaux des Agents Naturels et des biens incorporels.* Edition definitive revue et considerablement augmentée. Paris: Gauthier-Villars. [Price 7·50 francs each volume.]

Supplément aux Livres IV, V, *et* VI *du Cours d'Economie Politique de l'Ecole des Ponts et Chaussée. Statistiques de l'Année* 1913 *et Relevés rétrospectifs en France et a l'Etranger.* Paris: Gauthier-Villars. [Price 1·75 francs.]

How to Reduce your Income-Tax by Liberty Currency. By ARTHUR EDWARD SITWELL. London, New York and Toronto: Hodder and Stoughton. [Price 1*s.* 3*d.* net.]

What is Fair? A Study of Some Problems of Public Utility Regulation. By WILLIAM G. RAYMOND, C.E., LL.D. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 5*s.* net.]

The Elements of Hydrology. By ADOLPH F. MEYER, C.E. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 18*s.* 6*d.*]

United States Bureau of Mines. Bulletin No. 171. *Melting Brass in a Rocking Electric Furnace.* By H. W. GILLETT and A. G. RHOADS. Washington: Government Printing Office. [Price 20 cents.]

Mechanical World Year Book, 1919. Manchester and London: Emmott and Co., Limited. [Price 2*s.* net.]

Annuaire pour l'an 1919, *publie par le Bureau des Longitudes.* Paris: Gauthier-Villar et Cie. [Price 3 francs net.]

Whitaker's Almanack. By JOSEPH WHITAKER, F.S.A. London: 12, Warwick-lane. [Price 6*s.* net.]

The British Journal Photographic Almanack and Photographers' Daily Companion, 1919. Edited by GEORGE E. BROWN, F.I.C. London: Harry Greenwood and Co. [Price 1*s.* 6*d.* net; cloth bound 2*s.* 6*d.* net.]

Janes' Fighting Ships, 1918: *An Encyclopædia of the Navies of the World.* New and complete edition, containing all new British ships and those of the Allies hitherto banned by the Admiralty. Twenty-first year of issue. London and Edinburgh: Samson Low, Marston and Co., Limited. [Price 30*s.* net.]

The Theory of Modern Optical Instruments. A Reference Book for Physicists, Manufacturers of Optical Instruments and for Officers in the Army and Navy. By Dr. ALEXANDER GLEICHEN. Translated from the German by H. H. EMSLEY, B.Sc., and W. SWAINE, B.Sc. With an appendix on *Rangefinders.* London: Published for the Department of Scientific and Industrial Research by His Majesty's Stationery Office. [Price 12*s.* 6*d.* net.]

A Treatise on Gyrostatics and Rotational Motion. By ANDREW GRAY, F.R.S. *Theory and Applications.* London: MacMillan and Co., Limited. [Price 42*s.* net.]

Canal Control Committee (Board of Trade). Handbook on Canals containing Information relating to Controlled Canals, Lists of Towns Served by them, and Names and Addresses of Public Carriers. London: H.M. Stationery Office. [Price 6*d.* net.]

University of Illinois Engineering Experiment Station. Bulletin No. 105. *Hydraulic Experiments with Valves, Orifices, Hose, Nozzles and Orifice Buckets.* By ARTHUR N. TALBOT, FREDERICK B. SEELY, VIRGIL R. FLEMING, MELONI L. EUGEN. Urbana: Published by the University of Illinois; London: Chapman and Hall, Limited. [Price 35 cents.]

Loads on Highway Bridges. Report of Joint Committee of Representatives of the Concrete Institute, the Institution of Municipal and County Engineers, and the Institution of Municipal Engineers. With appendices by HENRY ADAMS and H. KEMPTON DIXON. London: E. and F. N. Spon; New York: Spon and Chamberlain. [Price 2*s.* 6*d.* net.]

THE LATE SIR BOVERTON REDWOOD, BART.

A FEW days of illness, heart failure following diphtheria last Wednesday, put an end to the long, active and successful life of Sir Boverton Redwood, who for many years and up to the last exercised a very prominent influence in the petroleum industry of this country, both commercially and technically. Born in London in April, 1846, a son of Mr. Theophilus Redwood, Professor of Chemistry to the Pharmaceutical Society, Boverton Redwood was educated at University College School, London, and turned to analytical chemistry. Petroleum was discovered in Pennsylvania while he was a boy. In 1869 he became secretary to the Petroleum Association, and that appointment was decisive for his career. When the Anglo-American Oil Company was established in this country, Mr. Redwood accepted the appointment of chief analyst for the imported oils of the Standard Oil Company. He had meanwhile, since the early 'seventies, been associated with Sir Frederick Abel in researches on the flash-point of oils, and he stood up for the low flash-point of 73 deg. F. until legislation raised that point after a long-contested inquiry. Redwood also took up the testing of oil generally; the Redwood discosimeter is still the standard instrument of this country. In the years 1885 to 1886 he was able to make, in conjunction with Sir Vivian Magendie, then chief inspector of explosives, extensive tours to study petroleum and its uses in Europe and America. Other long official and private journeys followed, and the manifold official tasks with which he was entrusted gave him most exceptional opportunities to acquire a thorough knowledge of petroleum and its technology and industry. Early in the 'nineties he was sent to the Suez Canal with respect to the transport of oil through the Canal. He was well acquainted with the oil refineries of the world. He was technical adviser to the Admiralty, the Home Office, the Port of London, and the Corporation of London. The outbreak of the war brought him in direct connection with other Government departments. Having been a member of the Royal Commission on Oil Fuel for the Navy since 1912, he joined the Petroleum Supplies Branch of the Ministry of Munitions in 1917; later he became Director of Technical Investigation on the Petroleum Executive, of which Mr. Long was chairman. As such he had to deal with problems of petroleum production and research, and in particular also with the development of British oil and oil fuels. At the same time he was chairman of the Gas Traction Committee. Many of these problems were, so far as publicity was desirable, discussed in the Institution of Petroleum Technologists, in whose foundation Sir Boverton had a large share, and whose first president he was for the period 1914 to 1916. He took a very active part in the proceedings of this body, and when he spoke there for the last time a few weeks ago, he looked quite as hale as many of the younger men present. He also interested himself in the study of petroleum technology at the University at Birmingham and in the Imperial College of Science. His well-known treatise on "Petroleum" came out in 1896, and saw its third edition in 1913, having swollen to three volumes. The "Handbook on Petroleum" was the joint work of himself and of Captain J. H. Thomson; this book was compiled for the use of inspectors under the Petroleum Act.

Sir Boverton was created a knight in 1905, and a baronetcy was conferred upon him in 1911. The title passes to his grandson, his only son having predeceased him. Sir Boverton was a Fellow of the Institute of Chemistry, and sat for several years before 1917 on the Council of the Chemical Society; he was also a Fellow of the Royal Society of Edinburgh. His D.Sc. degree was honorary, and bestowed by the University of Ohio. Arrangements for the funeral had not been made at the time of our going to press.

NATIONAL ILLUMINATION COMMITTEE OF GREAT BRITAIN.—In view of the imminent resumption of international co-operation in the study of questions connected with the art of illumination and the sciences related thereto, a meeting of the National Illumination Committee of Great Britain was held on Tuesday, May 27, at the Institution of Civil Engineers, when vacancies in the executive of the committee, due to the decease of Mr. W. Duddell, F.R.S., and Professor Silvanus P. Thompson, F.R.S., were filled. The executive, with the Institutions represented, is now as follows: Chairman, Mr. A. P. Trotter (Illuminating Engineering Society); vice-chairman, Mr. John Bond (Institute of Gas Engineers); and Mr. Kenelm Edgcumbe (Institute of Electrical Engineers); hon. secretary, Mr. Haydn T. Harrison (Institute of Electrical Engineers); hon. treasurer, Mr. W. J. A. Butterfield (Institute of Gas Engineers); representatives of the Executive Committee of the International Commission on Illumination, Dr. Harold G. Colman (Institute of Gas Engineers) and Mr. Leon Gaster, (Illuminating Engineering Society). The resumption of research work, &c., was considered, and a programme for further discussion at a meeting at an early date was settled.

THE INSTITUTION OF GAS ENGINEERS.

(*Continued from page* 700.)

WE left off our report of the proceedings of the annual general meeting of the Institution of Gas Engineers last week with the message from the Controller of Coal Mines on the necessity for continuing the exercise of economy in the use of coal.

Several members having expressed their views on the subject, the following resolution was passed: "That the members of the Institution of Gas Engineers view with much alarm the possible withdrawal of the Calorific Standards Order, and request the Council to make the strongest possible representations to the Coal Controller and the President of the Board of Trade as to the present position in regard to stocks of coal, and the serious effect on the supply of coal if the Order be withdrawn."

The next business brought before the meeting was the annual report of the council, and accounts, the adoption of which was moved by the president, and agreed to. After some statistics of membership, reference was made in it to the reports of the Gas Investigation, Refractory Materials, and Life of Gas Meters Research Committees, respectively, which had been presented and discussed at meetings of the Institution in June and October last. Representation on the newly-constituted National Gas Council had been arranged. In regard to the Institution Gas Research Fellowship, tenable at Leeds University, which had been in abeyance during the war, it was stated that it had been revived by the appointment to it of Mr. Thomas Hanby, B.Sc., who was engaged, under the direction of Professor Cobb, on an investigation on the decomposition of benzene and toluene, and its bearing on carbonisation. The annual amount payable in connection with the Fellowship had been increased to 200*l*.

The report gave the names of the representatives of the District Associations for the year 1918–19, affiliated with the Institution, and called attention to the alteration announced by the City and Guilds of London Institute with respect to its examinations. Under an arrangement made with the Board of Education the Institute had agreed gradually to abandon in England and Wales all examinations lower than the final, with few specified exceptions. Mr. S. Glover and Mr. W. Hole had consented to continue as examiners in Gas Engineering and Gas Supply, respectively, for another year. Mr. R. Halkett had resigned as examiner in Gas Fitting, and had been succeeded by Mr. H. Kendrick. The Council of the Institution had under consideration the question of methods of education and examinations. They had issued a further number of certificates to gas fitters, bringing the number up to 329. The report of the work of the Demobilisation Committee followed. Subsequent to the signing of the armistice its labours had been lightened by the formation of the Demobilisation, &c., Department of the Ministry of Labour, and its various branches, with which the committee had acted in conjunction whenever possible. The committee were of opinion that the gas industry generally is quick to respond to the claims of the ex-service man, particularly in regard to reinstatements, although cases occasionally arose—happily rare—in which the committee considered that something less than justice had been done. Allusion was made to the part taken by the Institution, with a number of other engineering and allied societies, in the movement for the amendment of the patent law. A deputation had communicated to the Board of Trade the following recommendations with a view to influencing the drafting of a new Bill, the Patent and Designs Bill of 1917 having been withdrawn: (1) A moratorium for patents adversely affected by the war; (2) the importance of protecting inventions relating to food, medicinal, and surgical products; (3) the importance of product claims to chemical and other industries; (4) the extension of (*a*) the terms of patents, (*b*) the period of provisional protection, (*c*) the period of acceptance of the complete specification; (5) the reduction of patent fees; (6) the protection of patentees in relation to the utilisation of their "patents" by the State; (7) limitation of provision for revoking patents; (8) safeguarding patents of addition; (9) the need for a special tribunal to deal with patent cases.

The council had adopted a report to the president on "Coal Conservation and the Coal Gas and Electrical Supply Industries of the United Kingdom," prepared by Sir Dugald Clerk, Professor Arthur Smithells and Professor John W. Cobb. It had been forwarded to the National Gas Council to be brought, with supplementary matter, before the Government and Ministry of Reconstruction, as representing the considered views of the gas industry on this important matter. A covering letter from the Institution accompanying this report contained the following: "In view of the claims put forward by the electrical industry for the saving of coal by the general use of electricity for the purposes of furnishing light, heat, and power to the community, the Council of the Institution consider it of the first importance that the comparison of facts stated in the report, incontrovertibly proving as they do the immensely superior advantage pertaining to the manufacture and distribution of gas, should without delay be placed in the possession of the authorities deputed to deal with the subject of coal conservation. It will be seen that the claims put forward on behalf of gas are argued in this report on the lowest possible basis of thermal efficiency, viz., on the basis of the thermal economy of the gas exclusively, all the loss in carbonising being debited against the gas, no portion being placed to the debit of the coke and tar products; the result being that the comparative economy of gas production is based on a thermal efficiency of 45 per cent., instead of the greater efficiency of 75 per cent. which might have been fairly claimed as the thermal result of the whole process. Little stress has been laid upon the home production of by-products in the tar, or of the sulphate of ammonia, both of which are essential to the country's needs, either during peace or in time of war. The same observation applies to the coke produced in carbonisation."

Other parts of the council's report had reference to the work done during the past year by the Gas Investigation Committee, the Refractory Materials Research Committee, and the Life of Gas Meters Research Committee. It was stated that good progress was now being made by each committee, additional research workers having been secured.

The Institution had become a constituent body of the Federal Council for pure and applied chemistry, Dr. H. G. Colman acting as its representative. The objects of this council are to advance, safeguard and voice the interests of chemical science. On the British Association Fuel Economy Committee the Institution is represented by Mr. D. H. Helps. Arrangements had been made for participating in the James Watt centenary celebration to be held at Birmingham. The council's report concluded with a statement in regard to the Waterways Association, in which the Institution continues its interest. The association had watched the trend of transport questions, and was more strongly convinced than ever that the improvements of the canals of the country, so as to bring them up to modern requirements, fitted for mechanical haulage and larger boats, will tend greatly to solve the transport problem. The position at the moment is that the operations of manufacturers everywhere are held up and delayed by the chronic congestion on the railways, which entirely fail to cope with the present traffic.

The second report of the Gas Investigation Committee was then considered, Professor Smithells, chairman of the Research Sub-Committee introducing it. At the opening of the report, after citing the *personnel* of the sub-committee (representatives of the University of Leeds and of the Institution) and referring to the preliminary report, it was pointed out that the importance of coal conservation is receiving general recognition, and although the gas industry stands in a particularly strong position with respect to it (since the thermal efficiency of the carbonisation process is from 70 per cent. to 80 per cent.), no opportunity of further possible economy should be missed. The calling into council by the Board of Trade of Sir George Beilby and the Fuel Research Board should ensure that any new legal standards adopted for public gas supply will not stand in the way of developments which tend to the further conservation of fuel, but will encourage them. The most direct line of progress for the gas industry is to secure a higher percentage of the heat of the coal in the gas, because no other form of fuel is capable of the same high degree of efficiency in all-round use. Gasification of the coke as water gas inside the retort or in separate generators is a simple means to this end. If blue water-gas is made separately no more is demanded than an extension of what is already practised in many gas works, with the modification, which is really a simplification, that carburetting is not essential. If water gas is made in the retort by steaming, the process is one which has already been worked to some extent, but is not general practice. It has possibilities outside the interaction of steam and carbon to form water gas, since the influence of an ascending gas on the descending charge and its products of decomposition in the retort is undoubtedly of importance in other ways as affecting the quantity and quality of all those volatile products, including motor spirit, fuel oil, and ammonia. Gases other than steam have also to be considered in this connection.

The committee had, therefore, welcomed the opportunity afforded by Mr. Lawrence Hislop and the Uddingston Gas Company in placing their installation of continuous vertical retorts at their disposal for the purpose of investigating the mode of manufacture just described, which Mr. Hislop has been practising for some time past. Dr. Parker, as research chemist, went to the Uddingston works at the beginning of February, and has been going through the ordinary preparatory work since that time, and has now started tests. The results are expected to provide definite and quantitative information on the working of this development of gas practice—a thermal and chemical balance-sheet of the process—of a kind which should prove of a high degree of usefulness, and of a completeness which has hitherto been lacking. It is plain, however, that the efficiency of this or any other process of production is dependent upon the efficiency of utilisation of the product. The position with reference to the steaming process or to the blue water gas process, as providing the possibility of increasing the percentage of the total heat energy of the coal carried by the gas, is that in either case the calorific power of the gas per cubic foot will be diminished. It was, therefore, of primary importance to make direct tests on the gas at Uddingston, deliberately made of a lower calorific value than that in common use to-day, in order to determine whether such gas, when made, was satisfactory and economical in use. Mr. James W. Wood, research chemist, went to Uddingston, and tests on the gas were made for both high and low-temperature uses. The incandescent mantle burner was taken as the appliance with most stringent requirements for high-temperature domestic use, and the ring burner as representative for low-temperature use. The results indicated that gas of the grade tested at Uddingston (approximately 400 British thermal units gross per cubic foot) could be used with a good efficiency in both low and high-temperature appliances, when the simplest possible modification of the burners tested was made by enlarging their nipple orifices.

Details, with tables and curves, of the tests were given at length, the apparatus and methods of working being as described in the committee's first report of the work at Birmingham last year. The gas used in the tests was made by steaming continuous vertical retorts, and was washed for benzole recovery before testing. Such gas has been regularly distributed in the district of Uddingston and represents a yield of 30,000 cub. ft. per ton of Lanarkshire coal carbonised. Throughout the tests the composition and calorific value of the gas have been steady (385 British thermal units to 394 British thermal units gross per cubic foot).

The summary of the experiments with ring burners showed that: (1) Those designed for gas of 500 British thermal units gross per cubic foot and upwards give trouble with lighting back and with inabilities to deliver heat units at a satisfactory rate when used with gas of 400 British thermal units gross as supplied at Uddingston, but both difficulties can be overcome by the simple process of opening out the nipple orifices to a suitable size and shape; (2) pressures at the burners above the normal are not required to work them satisfactorily, and lower pressures are permissible; (3) this gas of 400 British thermal units gave as good a thermal efficiency as any other grade with which the committee experimented, when used with a suitable modification of the burner, which can easily be made; (4) it follows that the gas of lower calorific value is not so good foot for foot as gas of a higher calorific value, but that the value in this use of different gases is directly proportional to the potential heat units they carry; (5) it would appear from comparison of the Birmingham and Uddingston results that probably on account of the composition and mode of combustion of this Uddingston gas, a given burner may be worked at rather a greater British thermal unit rate on the gas of lower calorific value, than on the higher, without loss of efficiency; the flames are rather shorter and do not smother so readily; (6) there are no unusual difficulties in manipulating burners with this gas, and the larger nipple orifices and less sensitive injectors required should reduce troubles connected with corrosion, stoppages, and necessary adjustments. These results obtained with, and reported for, ring burners are obviously directly applicable to all other burners for low-temperature use in which the same principles of construction are adopted.

Tests were carried out with low-pressure incandescent upright burners which showed that if burners correctly designed for gases of 500 British thermal units per cubic foot and upwards are simply modified by the enlargement of the nipple orifices they can be used without difficulty at pressures under twenty-tenths for this gas of 400 British thermal units, but if such modification is not made it is impossible to deliver the necessary number of British thermal units without excessive pressure, while trouble ensues with aeration and lighting back. With the modified burners no unusual manipulative troubles are encountered. With the "O" size mantle a perfectly steady light of some 70 c.p. to 75 c.p. is readily obtainable. This was obtained at a gas consumption of 6 cub. ft. to 6·5 cub. ft. per hour with a thermal efficiency of about 29 British thermal units net per candle-hour; with

one burner a much higher candle-power (153) was obtained with a thermal efficiency of 27·4 British thermal units net per candle-hour. Inverted incandescent burner tests were also carried out with a number of typical burners, the gas employed being very similar to that used for the ring burner and upright burner tests.

The relative efficiencies in use of different grades of gas (continued from the committee's first report) was dealt with in the next section. In it results were given of tests carried out using mixtures of coal gas and blue water-gas in different proportions, two large experimental gasholders being available, one filled with coal gas and the other with blue water-gas. Tests were carried out upon the coal gas, which was then diluted with blue water-gas from the other holder. After tests upon this mixture, the residual gas was still further diluted, and so on. As before, the burner was tested upon a 60-in. bar photometer, the illuminating power being measured in a horizontal direction through the centre of the mantle—*i.e.*, the maximum illuminating power. A number of curves and tables were given recording the results obtained, and the conclusion was expressed that it is plain that completely satisfactory comparison of the different gases can only be made when each is permitted to exercise its maximum duty in an appliance properly adapted to its use. The results of the experiments at Uddingston form an instructive commentary on this factor in the situation, indicating as they do, the extent of the benefits resulting from a simple enlargement of the nipple orifice on the one hand and a careful choice of burner on the other.

A discussion of the report followed. Professor Cobb, in the course of a sketch of the work of the committee, said he never appreciated personally until recently how peculiarly justified was the insistence upon the utmost care in the design and construction of appliances when the use of gas of very high calorific value was in question. With reference to inerts he desired to make a statement of facts that had only that morning been placed in his hands from quite recent experiments by Mr. J. W. Wood: If a straight coal gas of, say, 625 British thermal units gross per cubic foot is diluted with an inert constituent, nitrogen, until the calorific value is reduced by stages to 450 British thermal units gross, the mixtures so obtained show no differences of any practical importance as regards either attainable candle-power or thermal efficiency, provided that the heat units are delivered at the same rate.

Mr. Wood, the research chemist, followed with some observations, in which he stated that the burners used in the lighting tests were all selected as being in common use in the Uddingston district. Certain defects were noted, as the calorific value was reduced, but it was obvious that several of them, such as high pressures required and aeration troubles might be eliminated by very simple means.

Mr. Jacques Abady suggested that one of the tables of the report should be withdrawn as it seemed to show that it required more British thermal units to produce a candle-power as the calorific power dropped, and that of course was wrong. Professor Cobb replied that he believed the real answer to Mr. Abady was to be found in the substance of the report itself; and Dr. W. B. Davidson thought Mr. Abady's suggestion an unworthy one. Dr. Davidson expressed the opinion that the table in question represented the truth and the facts. He contended that one British thermal unit was not as good as another, and that it depended on the composition of the gas.

Mr. Leon Gaster thanked the committee for their work, and pointed out that if proper appliances were made to suit gas, and if consumers were made to understand the advisability of adopting those appliances, then competition with electricity would be on a fair basis.

Mr. Tim Duxbury described what had been done at Oldham, where they had been experimenting for eighteen months on various grades of gas. He assured the meeting that with the present quality of 410 British thermal units to 420 British thermal units every satisfaction was being given in lighting, heating and cooking.

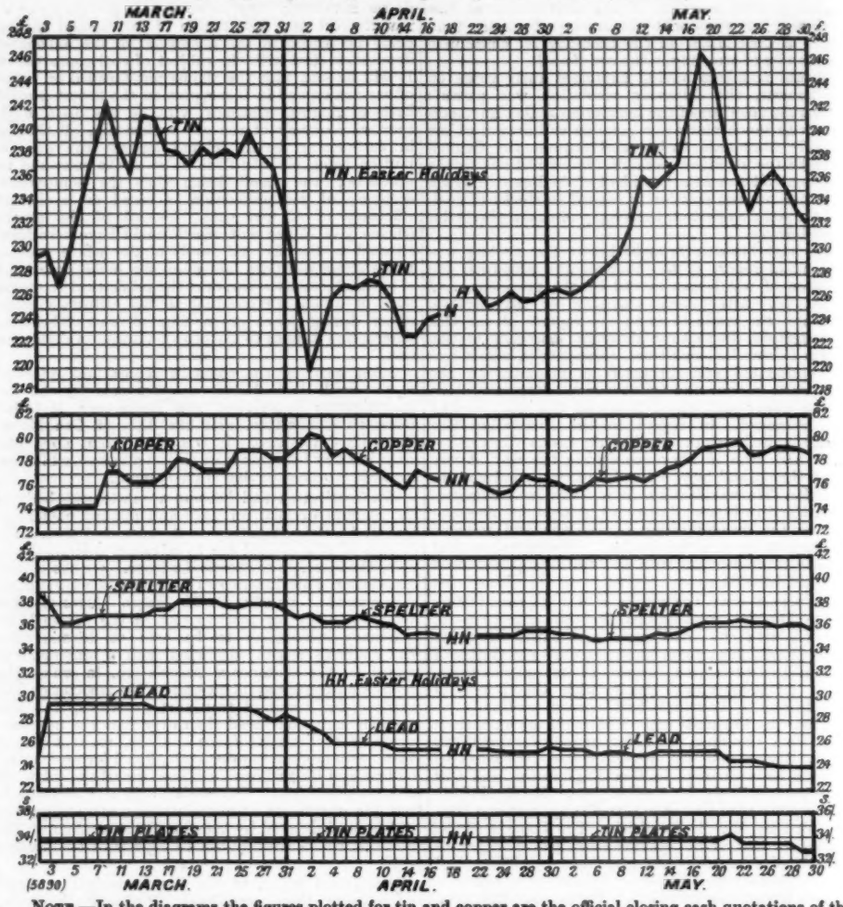
Captain Strange, member of the American Gas Association, remarked that Mr. F. C. Jones, chemist to the San Francisco Gas Company, some years ago brought to the attention of the association the rather remarkable coincidence that in a cubic foot of self-combustible mixture there was exactly 100 British thermal units, irrespective of whether the gas that was used contained originally 1,000 British thermal units or down to 320 British thermal units per cubic foot. That held good from 1,000 British thermal units, roughly, down to about 320 British thermal units. As to the co-operation of the appliance manufacturer and gas engineer, in the United States there was a very intimate co-operation. The public should know the important work the gas industry had done during the war. He was a thorough believer in the fairness of human beings, and if the public thoroughly understood what gas engineers were trying to do for their benefit he was sure the public's hearty support would be given them.

Mr. W. W. Townsend, of Colchester, suggested that the committee should revise its first report in the light of the second one. Mr. J. Kelly, of Bridlington, made reference to the report of the Fuel Research Board received by the Board of Trade. He thought it was of importance that it should go forth now that it would be very inadvisable to restrict the industry to 12 per cent. or any other percentage of inerts.

Professor Smithells, replying to the discussion, said the committee were always delighted to receive criticism. As to Mr. Townsend's suggestion for revision he pointed out that practical men who were investigating the subject on the committee had felt the right thing to do in the first steps of the investigation was to work with the appliances as the consumer had them, as the consumer was unable to alter them. When the time came to put before the public the complete summary of the work which had been carried out by the committee he hoped the order in which the committee would state its results would be such as to satisfy all sections of the gas industry. They were out to make inquiries regarding the efficiency of gas, and the efficiency in manufacture and use. It was inevitable that in the recording of the committee's progress there would be facts set down which would be understated, if what the committee had in mind was merely to show gas at its best, and it was equally true that there must be a good deal omitted that could be put in if the purpose was to advertise gas. He had not the least fear that, either by an unfavourable order of procedure, such as had been thought to be the case by Mr. Townsend, or by information included in or omitted from the report, the industry would suffer any damage in the end.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal Markets.)



NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange, as far as they have been reported, for "fine foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. The prices are per ton. The price of tin-plates is per box of I.C. cokes free on board at Welsh ports. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1l. each, except in the case of the diagram relating to tin-plates, where they represent 1s. each.

The proceedings of the first day were then brought to a close by the scrutineers' report of the election. Sir Dugald Clerk, K.B.E., D.Sc., was elected president, and 46 names were added to the roll of membership. Sir Dugald suitably acknowledged the honour which had been conferred on him.

(To be continued.)

MICA.—In reference to the Mica Control Order, 1918, dated April 15, 1918, the Minister of Munitions has ordered that the operation of the said Order is suspended on and after May 30, 1919, until further notice. Such suspension shall not affect the previous operation of the said Order or the validity of any action taken thereunder or the liability to any penalty or punishment in respect of any contravention or failure to comply with the said Order prior to such suspension or any proceeding or remedy in respect of such penalty or punishment. The new Order may be cited as "The Mica Control (Suspension) Order, 1919."

TRACTORS IN THE UNITED STATES.—A production of 314,936 tractors in the United States in 1919 is estimated by manufacturers reporting to the office of Farm Equipment Control, United States Department of Agriculture, says *The Board of Trade Journal*. The reports obtained in a special inquiry by the department show a production of 132,697 tractors in 1918. The figures for 1919, of course, are merely estimates, and represent the aggregate of the estimates submitted by the tractor manufacturers in January and February of this year. The following are the numbers of tractors of different horse-power which manufacturers estimate will be produced in 1919:—Makers' rating, belt horse-power: 9 h.p., 10 h.p. and 12 h.p., 8,220; 16 h.p. and 18 h.p., 48,545; 20 h.p. and 22 h.p., 157,671; 24 h.p. and 25 h.p., 40,875; 27 h.p., 28 h.p., 30 h.p. and 32 h.p., 27,465; 35 h.p. and 36 h.p., 5,435; 40 h.p., 45 h.p. and 50 h.p., 1,780; 60 h.p., 65 h.p., 70 h.p., 75 h.p. and 80 h.p., 1,536; not given, 23,409.

LARGE ELECTRIC STEEL-MELTING FURNACES.*

By VICTOR STOBIE.

Scope of Paper.—The early history and development of electric furnaces are a matter of general knowledge, and are not dealt with in this paper.

The author's commercial and technical experience with small and large electric arc steel-melting furnaces has led him to favour the latter for ingot making on account of the more advantageous costs and conditions of working of large units. The smaller furnaces have a very large field in foundry work. Observations will be confined mainly to the technical requirements of large plant and to some interesting phenomena on all furnaces.

Wiring Diagrams and Shapes of Furnaces.—The wiring diagrams (Figs. 1, 2, and 3) give what the author considers to be the best connections for three sizes of furnaces :—

Fig. 1 is for furnaces up to 6 tons' capacity : two-phase current, each phase maintained entirely separate from the other, with one end of each phase connected to separate electrodes above the bath and the other end of each phase connected to separate electrodes embedded in the hearth of the furnace at opposite ends of the furnace to their relative top electrodes.

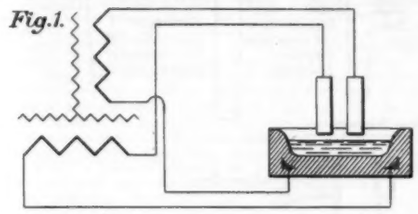


Fig. 1.

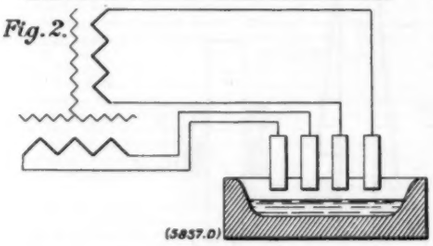


Fig. 2.

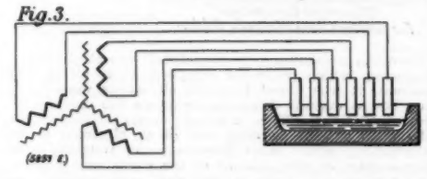


Fig. 3.

This arrangement gives exactly the requisite bottom heating for small furnaces and is characterised by the crossing of the currents in the direction of flow through the bath.

Fig. 2 is for furnaces from 6 tons' up to 24 tons' capacity : two-phase current, each phase maintained entirely separate from the other, with each end of each phase terminating in an electrode above the bath. Long experience has shown that bottom electrodes, whilst essential in small furnaces, are very undesirable in large furnaces.

Fig. 3 is for furnaces above 24 tons' capacity : three-phase current, each phase maintained entirely separate from the others, with each end of each phase terminating in an electrode above the bath.

The most favourable shapes for tilting electric furnaces would appear to be :—

Up to 6 tons : Rectangular in plan and in elevation with a curved bottom.

From 7 to 24 tons : Octagonal in plan.

Above 24 tons : Octagonal with lengthened back and front walls.

Stationary furnaces should always be rectangular.

The above shapes ensure the most convenient position for the electrodes in the furnace and help to keep the furnace walls at the average greatest distance from the electrodes, as illustrated in Figs. 4 to 6. It is most essential that electrodes should be in the positions shown and not opposite to doors, in order to avoid the breaking of electrodes when material is thrown into the furnaces.

A 5-ton Stobie electric steel-melting furnace is shown in Fig. 7.

Arc Phenomena.—The arc phenomena in a steel-melting electric furnace are very important and interesting. The arc proper jumps between the bath and whichever portion of the electrode is nearest to the bath. As this point is always changing, the arc travels irregularly round and under the lower extremity of the electrode, and is seldom at more than one point of the electrode at a time. The arc proper is the source but not the only point of heating of the furnace charge. A flame of carbonaceous gas, measuring in large furnaces as much as 2 ft. long, travels over the bath from each electrode. This flame is quite the hottest flame in commercial use and has great influence on the distribution of heat in the furnace. It is this flame which, by immediately travelling upwards in some designs of furnaces, causes therein excessively quick burning away of the roof and door arches. It will rapidly flux the banks of the furnace if allowed to impinge thereon.

Experiments were made at the Stobie Steelworks at Dunston-on-Tyne, near Newcastle, to obtain data as to the cause and effect of the direction of travel of the flame from the electrode.

Some control was obtained over the direction of the flame by alterations in the direction of rotation of the magnetic field of the supply currents. A certain change of direction of the flame resulted also from varying the phase reaching each electrode. The extent of the control over the flame was sufficient to make a decided change in the speed of working of a furnace and in the wear and tear of the lining. Unfortunately, no definite rule for guidance can be laid down at present, as the matter further depends upon the position of the flames in relation to each other, and, possibly, the magnetic fields external to the melting chamber.

Experiments on the blowing of the arc flames in

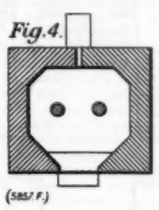


Fig. 4.

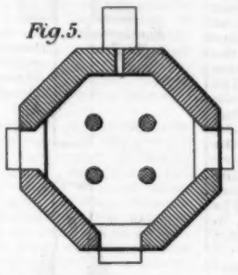


Fig. 5.

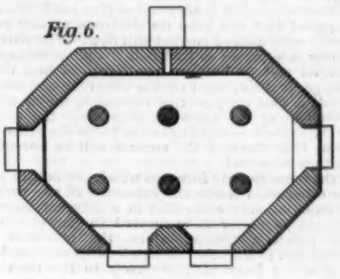


Fig. 6.

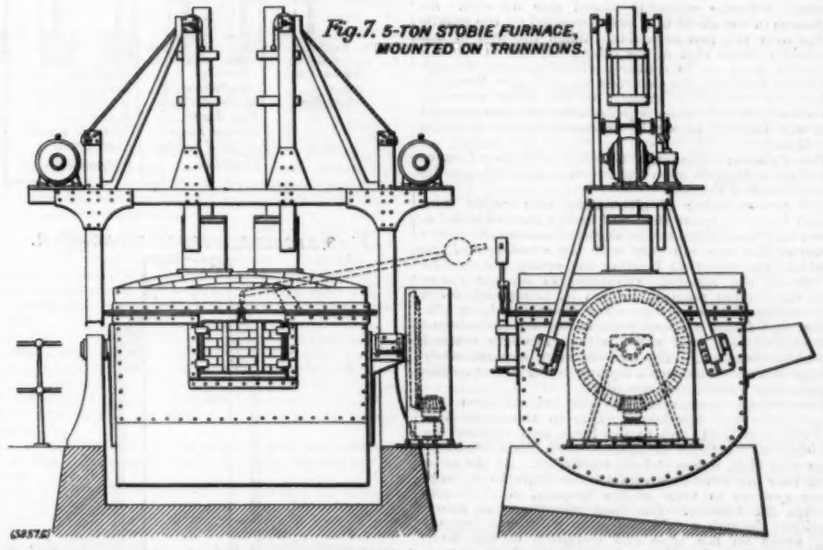


Fig. 7. 5-TON STOBIE FURNACE, MOUNTED ON TRUNNIONS.

furnaces by strong external continuous magnetic fields were then made in order to eliminate the uncertainty of coincidence of the revolving magnetic fields with some of the arcs in the polyphase systems of electric furnaces. Powerful lifting electromagnets were used for this purpose. Again, the many other factors existing within the arcing zones prevented any definite rule from being framed ; but by a careful disposition of the electrodes and cables in an installation so as to cause the magnetic fields coincident with certain arcs to blow the arcs in a desired direction, a most important increase in speed of melting and reduction in wear and tear of furnace lining are undoubtedly obtained.

In some types of electric furnaces arcs are maintained between adjacent electrodes and not between electrodes and bath. In such furnaces the property of inter-repulsion of arc flames is utilised in order to fan the flames over the material to be melted, whilst much of the heat energy in the circuit, viz., that in the arcs proper, travels only between the electrodes. This is the cause of the current consumed per ton of steel melted being high in such furnaces.

It was once believed that the great heat (*circa* 3,600 deg. C.) of the arcs in an electric furnace would have a detrimental effect on the steel. More recent experience teaches us that, so long as a steel is thoroughly deoxidised before casting, only the temperature of casting is of moment.

Transformers.—One might, with reason, say that the heart of the electrical equipment of an electric furnace installation is the transforming apparatus. Either through poor construction or short capacity a considerable number of transformers attached to early furnaces gave trouble. The stresses which the transformers have to resist are of an exceedingly heavy order. The plant has to withstand occasional short-circuiting through the furnace and, perhaps once or more in its life, the equivalent of almost a dead short-circuit. It has to allow frequent breaking of the circuits under heavy overload and, should the furnace hands be careless and the plant be unprovided with proper protective devices, of occasional switching direct on to overload.

The requirements in the design of the transformers are :—

(1) That the current density of both the low-tension and extra-high-tension windings shall be low enough to prevent the inevitable overloads from unduly heating up and deteriorating the insulation.

(2) The ventilating channels in the windings must be specially well considered so as to provide low resistance paths for the cooling oil without excessive magnetic leakage.

(3) That windings shall be braced on all sides.

(4) The low-tension windings shall be taped with such material as empire tape, in addition to press-spahn or similar stiff insulation.

(5) All clamps, no matter how small they may be, should be anchored to the transformer frame work.

(6) The whole of the apparatus must be as unyielding to magnetic stresses as mechanical skill can make it.

(7) As much as possible of the total reactance required in the whole of the furnace installation should be incorporated in the transformers.

A very few years ago furnace transformers were built upon very different lines from the above. In the year 1915 the author first specified the taping of the low-tension winding of furnace transformers and the anchoring of all clamps, the reason for these requests being that several transformers had broken down through the meeting of two lengths of low-tension copper above the windings, and that the shrinkage of wood composing parts of clamps allowed several clamps to fall and the tightening bolts had narrowly escaped short-circuiting the low-tension windings. The above practice has now become general for furnace transformers.

As a result of observations of the breakdown of some furnace transformers, the bracing of all sides of the windings of transformers was specified by the author in 1917, and a shell type of transformer embodying that feature was designed in collaboration with a well-known transformer firm. The design has now been standardised also for large power transformers.

It is usual to have several tappings brought out from the high-tension windings of furnace transformers, as the voltage required on a furnace during melting is always higher than when finishing a heat. All such tappings should be brought away from the central portions of the winding, the complete high-tension winding being divided into two at the mid-point and the tappings bridged across the mid-point to cut out equal portions of each half of the windings when required. By taking the tappings out in this way, the insulation

* Paper read at a joint meeting of the Institution of Electrical Engineers and the Iron and Steel Institute, on Thursday, May 8, 1919.

of the end turns of the high-tension windings can be suitably reinforced to withstand any abnormal voltage stress on switching in the transformers.

On the practical side, useful results have been obtained at the Stobie Steelworks by limiting the current density in transformer windings to 1,250 amperes per square inch, the induction in the iron to about 12,000 C.G.S. lines, and the temperature rise on continuous full-load to 45 deg. C., measured by the increase in resistance. In addition to pressure-testing at twice the working voltage, an over-potential test at this double voltage is made on the high-tension side, the periodicity being increased to keep down the magnetising current. The low-tension windings of large furnace transformers should be tested at a potential several times greater than normal by being connected in series, the low-tension coils almost invariably being designed for parallel working.

Automatic Electrode Regulators.—A few observations on automatic electrode regulators from the furnace user's point of view may be useful. The desiderata in automatic regulation mechanism include sensitiveness without fragility, and simply setting to limits. If the furnace circuits contain two arcs in series, it is necessary that the energy in each such two arcs should be balanced, whatever current is flowing. This is accomplished in Stobie electric furnaces by operating one electrode motor by an automatic current controller and the other by an automatic potential controller. The current controller is adjusted to give the limits of current required and will keep its electrode at any position at which such desired current will flow. The potential controller is adjusted so that half the phase voltage, i.e., the normal voltage between one electrode and the furnace charge, is maintained on the electrode it controls. The result is that the potential-regulating motor will keep its electrode at the same distance from the molten steel as the current-regulating motor keeps the other electrode, as at that distance the current will be normal and the voltage balanced.

On some electric furnaces which the author is building for other steel works the balancing of two arcs in series is automatically controlled in a different manner. The current regulator is connected to one electrode as in the previous system, whilst the potential regulator connected to the other electrode is operated as follows :—

A shunt from each electrode to the bath is passed through separate solenoids placed side by side. An armature in the shape of a bar suspended by the middle hangs over the two solenoids. When the pull of one solenoid exceeds that of the other, one end of the bar is pulled down on to contacts which operate, through contactor switches, the electrode motor in one direction. When the voltage is greater on the other solenoid, the other end of the lever is pulled down by that solenoid and the electric motor is operated in the opposite direction.

Power Factor.—The power factor of an electric furnace installation depends upon the circuit reactances and the power factor of the arc.

The power factor of alternating arcs varies from almost unity to lower than 0·7 in the case of arcs between cold hard metals. In electric furnaces the power factor of the arcs will vary with the steadiness of the arcs and the materials forming the arcing points. As is known, the apparent resistance of an arc varies with the current passing through it, being high for a low current. The voltage wave consequently is distorted and forms a sharp peak at the commencement and end of each half cycle, with a strongly marked depression between. The current wave approximately retains its sine shape, and a lagging power factor results without any phase displacement.

The circuit reactances are divided between the transformers and the leads. Due to the large sizes of conductors used, and to the large area enclosed by the circuits, reactance in furnace work has a tendency to be very high, unless strictly controlled. At the same time, very low reactance would be undesirable on large power systems in view of the frequent short-circuits through the furnace. The total impedance on short-circuiting through a cold charge in a furnace depends very much on the type and condition of the scrap being melted, and will usually be quite high enough to reduce all shocks to reasonable limits. If, however, a short-circuit takes place through a molten steel bath, the impedance will be relatively low on account of the good conductivity of the bath, unless a reasonable amount of reactance is incorporated in the circuits. Such short-circuits are, fortunately, very rare in well-designed furnaces.

The total impedance at the moment of starting a large furnace with poor scrap sometimes reaches over 90 per cent. With average scrap it ranges between 40 per cent. and 60 per cent. When melting armour scrap or other clean heavy material it little exceeds the reactance.

A 15-ton Stobie furnace gives the following power factors :—

On melting	0·84
When charge is half melted	0·85
When charge is almost melted	0·87
When charge is melted	0·93

The average (in relation to the magnitude of the load) power factor over the total of units consumed at the Stobie Steel Company's works, including all motors for fitting shop, cranes, furnace auxiliaries and the furnaces themselves, varies between 0·86 and 0·88. The furnace load is about 90 per cent. of the total load, and the balance is taken by intermittent lightly-loaded low-power-factor motor circuits. It can, therefore, be safely stated that large furnaces such as the 10-ton, 15-ton, and 20-ton Stobie furnaces give an average power factor of fully 0·88 over all units consumed.

The author has heard it stated at various times that one or other particular design of furnace can be worked safely at almost unity power factor. Sooner or later one hears of the collapse of some part of such gear due almost certainly to serious current surges. Considerable experience in the designing and operating of electric furnaces teaches one to aim for safety before unnecessarily high electrical performance, and this rules out of consideration furnace installations with less than 20 per cent. impedance voltage when short-circuited across the electrode terminals. The author aims at installing plant in such a manner that on dead short-circuit the power factor is momentarily reduced to 0·4 or even 0·3. This need not mitigate against the excellent normal power factors already mentioned.

Electrode Considerations.—The presence of electrodes in electric arc furnaces is, for the user and designer, an unfortunate necessity. The function of the electrodes is to conduct the current into the furnace and to produce an arc gap in each electrical circuit, in order to localise, as far as possible, the conversion of the current into heat at the requisite points in the furnace. The desirable characteristics of an electrode are: low resistivity, relative incombustibility, and cheapness. No material combines these qualities. The nearest approach is found in carbon, and one has the choice between amorphous and graphitic carbon electrodes. The resistivity of the amorphous variety is, roughly, four times that of the graphitic. This enables graphitic electrodes to be made of smaller diameter than amorphous ones for equal current-carrying capacity. The following table gives the comparative data of both types of electrodes, including the diameter of electrode sufficient to carry, in practice, 10,000 amperes safely :—

—	Specific resistance per cm. cube.	Lowest temperature of combustion.	Diameter to carry 10,000 amperes.
	ohm.	deg. C.	in.
Amorphous electrode	0·00332	513	12
Graphite electrode	0·00114	624	20

Graphite electrodes have not, in the author's opinion, progressed among electric furnace users so well as they would have done had unsupportable claims not been made in their favour. This is a matter which would not concern this paper but for a very important point, almost invariably overlooked by designers and users of electric furnaces, which should be ever in mind when considering the engineering features of large electric furnace installations. This point is "skin effect."

The early users of graphitic electrodes obtained their experience on non-ferrous furnaces using direct current.

Fig. 8. EFFECT OF STOBIE ECONOMIZERS, COMPARED WITH ORDINARY METHODS OF SEALING CONTINUOUSLY-FED ELECTRODES IN ELECTRIC STEEL-MELTING FURNACES.

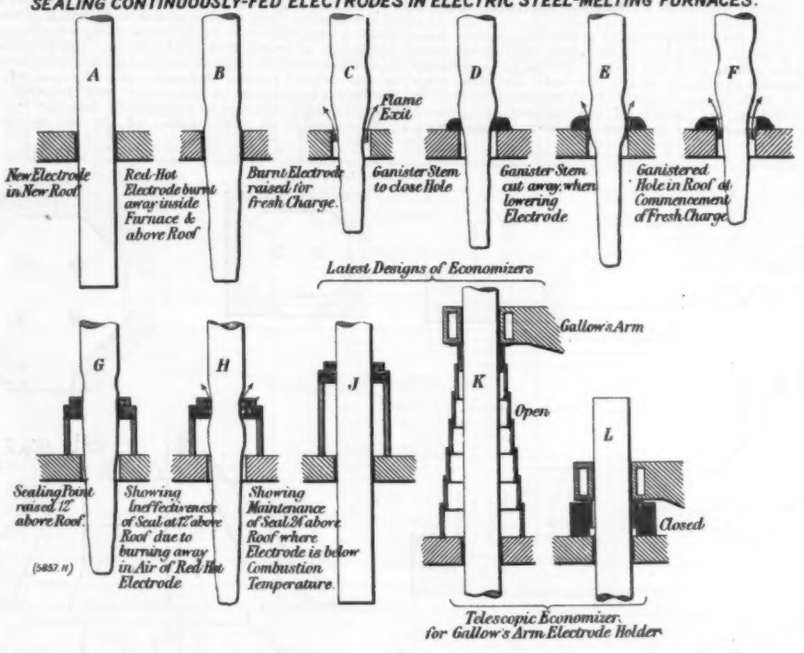
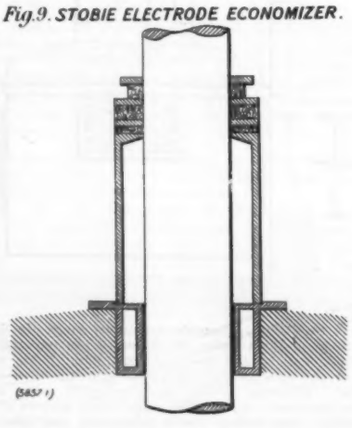

A
B
C
D
E
F
Flame Exit
New Electrode in New Roof
Red-Hot Electrode burnt away inside Furnace & above Roof
Burnt Electrode raised for fresh Charge.
Ganister Stem to close Hole
Ganister Stem cut away when lowering Electrode
Ganistered Hole in Roof at Commencement of Fresh Charge
Latest Designs of Economizers
G
H
J
K
L
Gallow's Arm
Open
Closed
Sealing Point raised 12" above Roof.
(5857 H)
Showing Ineffectiveness of Seal at 12" above Roof due to burning away in Air of Red-Hot Electrode
Showing Maintenance of Seal 24" above Roof where Electrode is below Combustion Temperature.
Telescopic Economizer for Gallow's Arm Electrode Holder

Fig. 9. STOBIE ELECTRODE ECONOMIZER.



When the electrodes were introduced into steel-melting furnaces, which were all supplied with alternating current, it was found that the electrodes were much too hot at current densities far below the maker's recommendations. The average current density in the main current-carrying area of an electrode in an alternating-current steel furnace being roughly twice the average current density of the whole area, due to skin effect, the electrode will not usefully carry as heavy a total current as is generally claimed. This same phenomenon will attain considerable importance in other parts of large furnace plant and lead to great loss of energy and materials, unless studied in detail.

The main consumption of the electrodes in ordinary electric steel furnaces does not take place at the arcing end of the electrodes, but results from the surface burning of the carbon all over those parts of the electrodes which are inside the melting chamber and up to a point about 15 in. above the roof. On looking inside most furnaces the electrodes will be seen to be considerably tapered from where they enter the roof down to the arcing ends. Fully 75 per cent. of the heavy expenditure on electrodes is wasted through this defect. Various attempts to prevent this costly waste of electrodes have been previously made, such as (1) enveloping the carbons with asbestos paste held in position by wire netting; (2) coating the electrodes with non-burning paints; (3) encircling the electrodes with steel collars held together by hinges or springs; (4) surrounding the electrodes with water-cooled cylinders extending well inside the furnace. All such methods have met with failure because, by the first method, the asbestos perishes quickly inside the melting chamber and is expensive to apply; in (2) the non-burning coatings all expand and fall away from the non-expanding carbon electrode; in (3) the collars do not protect red hot electrodes from the air above the roof, the collars are not efficient in keeping back the flames but have a very short life and are expensive in upkeep; and in (4) the internal jackets are most wasteful of heat and, further, are dangerous inside the furnace and very ineffective.

It is thought by some people not acquainted with electric furnace practice that there is always a reducing atmosphere inside electric furnaces of the older types in use. This is an utterly mistaken notion, which is proved by the ease with which the raw materials charged into such furnaces oxidise, even without the help of iron ore or other solid oxidant.

The cause of the oxidising atmosphere inside the older electric furnaces is the crude method of feeding the electrodes into the melting chamber. This is usually

done by leaving in the roof a number of plain holes equal to the number of electrodes which have to be continuously fed into the furnace; the bricks forming such holes support annular water jackets which fit, with a small clearance, new electrodes. The heated gases inside the furnace continuously pass up those clearances between the roof and the electrodes. The results are manifold: it causes the clearance to be rapidly increased by the flames burning away the electrodes to a tapered point as previously explained; it wastes all the heat value of the gases and flames which are constantly pouring out of the furnace through the electrode holes; it lengthens the duration of a charge in proportion to the heat lost through the roof holes; the escaping flames cause the electrode gear and current conductors over the roof to deteriorate rapidly; and the undue heating of the electrode terminals necessitates their being water cooled. The considerable effect of all this on the cost of producing the steel, quite apart from some loss of control therefrom over the operations of the furnace, will be readily apparent.

At first sight it may seem a simple matter to close up the clearance between the roof of a furnace and the electrodes passing through it; but the following will illustrate some of the difficulties.

It has often been attempted to make the water coolers round the holes a sliding fit on the electrodes. To enable this to be done the electrode must be machined to size; a most expensive detail when amorphous electrodes are used. When the machined electrodes are placed in position, the parts which are inside the melting chamber become white hot. Every time an electrode is raised—a constant operation in electric steel melting—some white hot or bright red hot part of the electrode is raised into the air above the furnace roof and burns away at the surface to a small or great extent. Each such reduction in diameter of the electrode commences or increases the clearance between the water jacket and the electrode, thus only delaying for a few hours the state of affairs existing in furnaces which start with the usual large clearance round the electrode.

The difficulty has now been successfully overcome in a simple way. Observations showed that at about 2 ft. above the roof in most furnaces the electrodes, even when raised for charging, are seldom at a temperature at which they can burn; therefore, that is the only point at which a permanently good seal can be made round the electrodes. If an electrode is closed hermetically from the roof up to that point, the burning away of the electrode and the escaping of the heated gases from the furnace are prevented.

In practice, a light metal cylinder a few inches larger in diameter than the electrode and about 2 ft. in length is fixed on the roof round each electrode. The top end of the jacket is covered with a sealing plate which prevents the passage of the flames, the electrode passing through a neatly fitting hole in the centre of such cover. Fig. 8 illustrates the effect of the apparatus.

In this figure A shows a new electrode when first placed in an electric furnace.

B shows the effect when the electrode has been in use for a few hours. The surface inside the furnace is burnt away by the internal atmosphere and, as the electrode is red hot above the roof, the electrode also burns away there in the free air.

C shows the effect of raising the electrode for melting a fresh charge. That part of the electrode where the surface has been burnt away inside the furnace has to be raised partly above the roof. This results in an immediate extension of the clearance between the electrode and the electrode hole in the roof. The result is that the flames rush out of the furnace through the roof and rapidly burn away the electrode.

D illustrates the usual way of sealing the electrodes. Ganister or similar material is thrown against the electrode to seal up the clearance in the electrode hole.

E shows how the ganister stem is cut away by the electrode when the latter is again lowered.

F shows the uselessness of the ganister stemming immediately the electrode is again raised, due to the thick part of the electrode having created almost as much clearance between the electrode and the ganister as there was between the electrode and the original roof hole.

G illustrates the earliest attempt the author made to remove the sealing of the electrode away from the roof. This was not successful because of the still red hot electrode above the roof burning away in the air.

H illustrates the result of the above short economiser. From this drawing will be appreciated the very small advance that this or any other short seal constitutes over the early methods of sealing.

J (Fig. 8) and Fig. 9 show the present-day economiser which forms the subject of letters patent. It is only by removing the electrode seal to a position well above the roof where the electrode is always below combustion temperature that the effectiveness of the present scheme is obtained.

K and L show the same principle of economiser in telescopic form suitable for furnaces having only a short electrode travel. The conditions that exist in an electric steel furnace are even more onerous than an inspection of these drawings would lead one to assume The reason for this is that electrodes are not raised only when a fresh charge is put into the furnace, but they are being raised or lowered constantly for the ordinary regulation of the current on the furnace. The effect of this necessary regulation is that the electrodes are moved an average of once each 5 seconds to 10 seconds during the first third of the process, an average of every half minute during the second third, and an average of every minute during the last portion of the process.

This most important advance in electric furnaces gives results much beyond what might be expected from so simple a device, several of the improvements being as follows:—

1. No cold air is drawn into the furnace.

2. No flames or highly heated air burn away the electrodes above the roof.

3. A really reducing carbon-depositing (when desired) atmosphere is maintained within the melting chamber.

4. The oxygen-free atmosphere of the furnace prevents the burning of the electrodes inside the furnace except at the arcing ends and, therefore, electrodes remain parallel instead of tapering.

5. The electrodes can be of smaller diameter for a given current supply. This, in addition to cutting down electrode costs, permits a reduction in the size of the electrode holes in the roof, thereby adding great strength to the roof.

6. The life of the roof is considerably increased because the thick carbonaceous atmosphere inside the furnace acts as an opaque curtain through which the intense heat of the arcs cannot be radiated upwards to the roof.

7. The flames inside the furnace, not being able to pass out at the electrode holes, travel all over and among the charge and heat this up rapidly and very economically.

8. The electrode gear over the furnace does not become intensely hot as in older furnaces. Any adjustments required in the electrode gear over the roof can therefore be done in comfort by the furnace attendants while the furnace is at top heat. The coolness of the gear renders the frequency of such adjustments negligible. In the same way the absence of the great columns of flames, which continuously rise through the electrode holes of other furnaces and which radiate intense heat all around, renders the Stobie furnaces much cooler to work.

9. In consequence of the exclusion of free air from the furnace, and the absolute control which this permits over oxidation, scrap steels containing oxidisable elements such as chromium, tungsten, manganese, and even vanadium, can be easily melted without losing the special elements from the bath. In other furnaces the major portion of such elements is first oxidised out of the charge into the slag and has then to be skilfully recovered, if possible, at great expense in time and current. When melting scrap which it is desired not to change at all in analysis, the carbon content does not vary by more than a point up or down. It is thus not necessary to analyse the molten bath in order to adjust the carbon and other elements when melting scrap giving the arithmetical proportions of the desired composition.

10. The absence of heat from the electrode gear enables the current terminals of the electrode to be made of light copper contacts built up of standard copper bars, instead of the usual intricate, heavy, water-cooled bronze castings necessary in other designs.

11. By preventing the heavy heat losses which formerly took place, the cost of manufacturing electric steel has been correspondingly reduced and the time required per heat diminished.

12. The sealing of the roof of furnaces by means of the economiser results in the furnace being much cooler for the furnace men to operate. This and the increased output from the plant very greatly reduce labour considerations for a given output of steel. This is of great moment nowadays in view of the high cost of labour.

Circulation of Bath.—Claims are made by some furnace manufacturers that, by reason of the electrical system or the position of the current circuits in their furnaces an automatic stirring or circulation of the molten-metal bath takes place. It is also claimed that, in consequence of such circulations, no manual rabbling of the charge is necessary.

A careful research on the subject has been carried out at the Stobie steel works and the results are of interest.

Many years' observation of the working of electric steel furnaces had not revealed any movements of the steel bath except such as were due to well-known causes; therefore it was decided to devise means whereby closer observation of the effects of electric circuits through molten metal could be made than was possible in a steel furnace working at temperatures up to 1,800 deg. C. Mercury presented itself as a suitable substitute for a hot steel bath, as it resembled molten steel in being a liquid metal and magnetically inert. The resistivity of mercury at atmospheric temperature is approximately two-thirds that of molten steel. Its specific gravity is twice that of molten steel.

Separate experiments with single-, two-phase, and three-phase currents, and representing every known type of furnace with arcs playing on the bath, were made.

The size of the bath, the quantity of mercury, and the current flowing were proportioned to represent average practice, but on a reduced scale. Two voltages were separately used for each system of connections: one low enough to enable the full current to be passed through the bath without arcs, and a higher one to pass the current through arcs above the bath as in normal steel melting.

All the different furnace systems exhibited the same effects when current was switched on.

At low voltage, with the electrodes immersed in the metal, the observed motion of the bath consisted of a very faint pulsation coincident with the periodicity of the current. The amplitude of the pulsation was greatest near each electrode and diminished with distance according to the law of inverse squares. These vibrations which originated at each electrode were so small that they were detected at the surface only by the minutely throbbing reflection of incident rays. There was no trace of a circulating or swirling motion in any part of the molten bath.

As solid conductors heavily loaded with alternating current always vibrate, it was considered that the minute waves observed in the mercury bath might originate from the vibration of the electrodes immersed therein and not from the passage of the current through the liquid metal, in consequence of the much greater area of the latter. Therefore the current was next made to flow round entirely-insulated copper circuits immersed in the bath. The same types and strength of electric current were employed as in the previous experiments. Exactly the same pulsations were noticed at the surface of the bath and a total absence of flowing motion.

The flowing movement of the slag under the arcs, visible in an electric steel furnace when the bath is covered with a fluid slag, has doubtless given rise to the common belief in a stirring of the metal bath by the current. The movement in the slag results, however, from the blowing action of the electric arcs, and it will stop immediately if the electrodes be lowered into the slag.

During the course of the above experiments it was noted that the greatest pulsating disturbance of the mercury was when the arcs played directly upon it. That disturbance was purely local and diminished considerably when a highly conducting fluid "slag" was placed on the metal. The violence of the blowing action of an alternating arc on liquid metal is observed in a commercial electric furnace if an arc is struck on to the bare steel after the removal of the slag. The steel will be blown away downwards from the electrode end and, on rebounding, will usually short-circuit the arc. The addition of a fluid slag will relieve the metal of the disturbance, as the slag will take up the flowing effort. The research conclusively proved that no circulatory or other stirring movement of the bath results from the electrode circuits in an electric arc furnace. The more or less complete diffusion of added elements which takes place in a bath of molten steel is a metallurgical phenomenon that occurs in all steel-melting furnaces, whether electric or other, and does not depend upon magnetic or convection currents, No special conditions exist in any electric arc furnace which will relieve the good steel melter from the necessity of properly rabbling his furnace bath.

SOME EXPERIMENTS ON FULL CARGO SHIP MODELS.*

By JAMES SEMPLE, Member.

THE great demand for cargo ships during the past year or two has directed the attention of experimenters in a special way to the subjects of the resistance and propulsion of this type of vessel. Experimental data dealing with this question are not altogether lacking, Mr. G. S. Baker, in particular, and also Professor H. C. Sadler (U.S.A.) having, in certain directions, explored the field of investigation.

Whilst there is a danger of experimental investigations overlapping, no harm can arise from corroborative evidence, and some points are of such importance that the attention of shipbuilders cannot be too frequently directed thereto.

The present paper contains some results of experiments made in order to determine on ships of average proportions the effect on performance (*a*) of fullness, and (*b*) of longitudinal distribution of displacement. Wake and thrust deduction investigations were also carried out on a number of the models, and in addition some comparisons are drawn between the results obtained at Clydebank, and in other establishments.

The results are given in (C) curves on a base of (L), where (L) $= 1{\cdot}055\frac{V}{\sqrt{L}}$. The members of this Institution are now familiar with (C) curves, Froude and Baker having kept to this form of presentation. Froude however, presented (C) curves on a base of (K) and Baker on a base of (F); the reason for departing from these practices is that the first results obtained in our tank was plotted on a base of (K), but when certain series of models were run embracing altogether 45 (C) curves it was found that the fairing of these curves could be more easily accomplished with the values plotted on a base of (L) rather than on that of (K). Had Mr. Baker's (F) value (which brings into common positions the humps and hollows of the (C) curves of models of varying fullness) been known at that time, it is more than probable that this value would have been adopted in preference to that of (L).

Effect of Fullness on Performance.—In this series a length of 400 ft. was associated with a beam of 53·33 ft. Whilst the breadth of merchant ships on the broad average equals $\frac{L}{10} + 10$ ft. there is a decided tendency to exceed this proportion, especially in full cargo vessels. Further, on the average, the load draught of cargo ships does not greatly vary from 0·45 beam, therefore it was considered that a draught of 24 ft. would be suitable.

* Paper read before the Institution of Naval Architects, April 11, 1919.

Four models were made to the proportions thus arrived at, the prismatic coefficients being respectively 0·75, 0·77, 0·79 and 0·81. The amidship section was made very full and the centre of buoyancy placed 0·25 per cent. L. aft of amidships.

The particulars of the vessels were therefore as given on the first table on the opposite page.

Fig.1. CURVES OF AREAS OF MODELS A.B.C.D

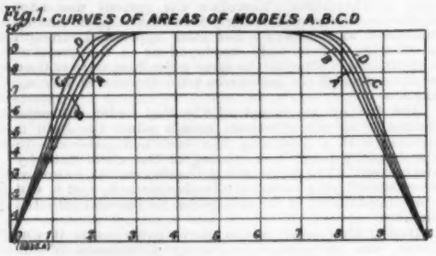


Fig.3. CURVES OF AREAS OF MODELS E.F.

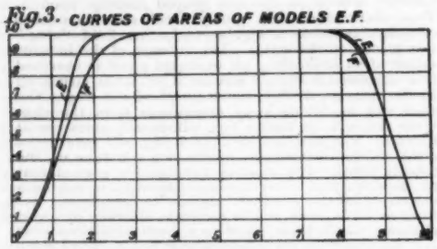
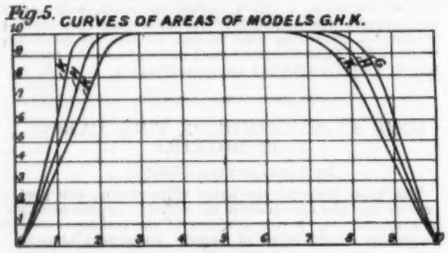


Fig.5. CURVES OF AREAS OF MODELS G.H.K.



In this table δ = block coefficient,
ϕ_F = prismatic coefficient—fore body,
ϕ_A = prismatic coefficient—aft body,
β = amidship area coefficient.

Experience shows that certain instability of result occurs when models are run at very low speeds; accordingly for full vessels the models were made as large as could be conveniently handled, so that the resistances measured might be as large as possible and the critical speed of the model removed as far from the zone of instability as practicable. Consequently the models were made 200 in. in length.

The speed corresponding to 11 knots for a 400-ft. ship of a model 200 in. long is 227 ft. per minute, and even at this speed results cannot be reproduced with certainty. It has been the practice at Clydebank to run the models at at least three and frequently at five draughts, so that the results may be faired in, and the possibility of considerable error reduced to a minimum. In the present case the models were each run at five draughts.

The curves of areas of the four vessels "A," "B," "C," "D," appropriate to 24 ft. draught, are shown on Fig. 1 above, and the results on Fig. 2. In Table I, on the opposite page, the full results and particulars of models are given. A definite increase in (C) value accompanies increase in fullness, and the (C) curves at constant draught rise much more steeply in the full models than in those which are finer. Even in the fullest model, however, the increase in (C) is not prohibitive until an (L) value of about 0·74 is reached, which corresponds to a speed of 14 knots for a 400-ft. ship. In examining the variation of (C) with variations in draught in Table I it will be observed that these—especially in models "B" and "C"—rapidly decrease with increase in draught, thus showing the importance of making the most of the draught dimension where economical propulsion in this type of ship is desired. If an efficiency of propulsion of 50 per cent. be assumed, the Admiralty constant which would be obtained by "C" vessel at the light draught, at 11 knots speed for a 400-ft. ship, *i.e.*, (L) = 0·58, would be 258, whereas at the deepest draught that figure becomes 279, and this notwithstanding that a fuller vessel results from the increased draught.

Shortly after this series of models had been run a form was tested in which the transverse sections embodies the straight-frame principle. The model was tried, and gave very different results. This was, without much consideration, attributed to the nature of the sections. Subsequently it was suggested that by altering the prismatic curve aft some improvement of result could be effected. In the light of previous experience an increase in draught and a decrease in fullness was known to be advantageous. Accordingly a new design was produced to a slightly deeper draught, the block coefficient was reduced and a finer run given. The new model gave a much improved performance compared with that preceding. The sectional area curves of these models, designated "E" and "F," are shown on Fig. 3, and their (C) and E.H.P. curves on Fig. 4 on this page.

Fig.2. (C) *Curves for 400 Ft. Length and E.H.P. Curves of Vessels corresponding to Models A.B.C.D.*

L-Length in Feet
B-Breadth in Feet
D-Draft in Feet
δ-Block Coefficient
Δ-Displacement in Tons
V-Speed in Knots

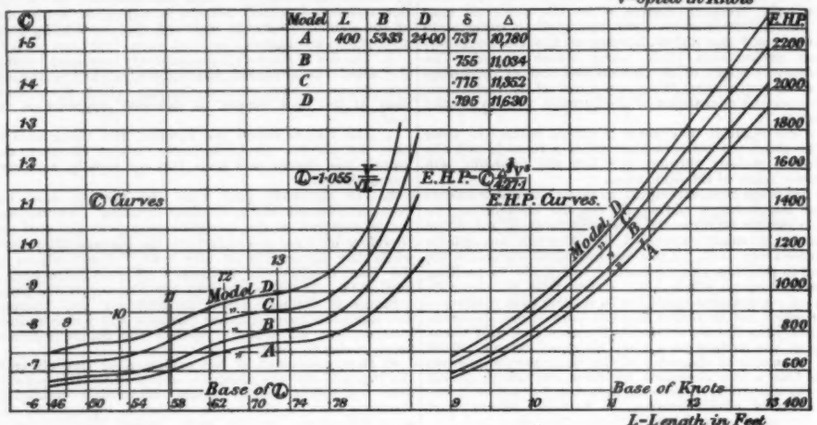


Fig.4. (C) *Curves for 400 Ft Length and E.H.P. Curves of Vessels corresponding to Models E.F.*

L-Length in Feet
B-Breadth in Feet
D-Draft in Feet
δ-Block Coefficient
Δ-Displacement in Tons.
V-Speed in Knots

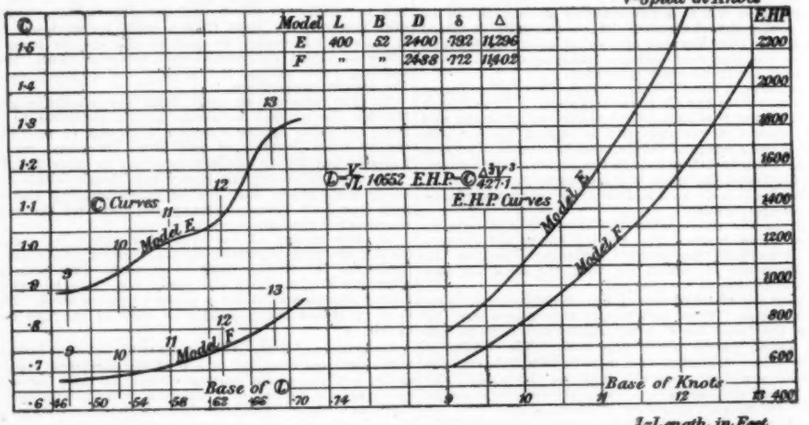
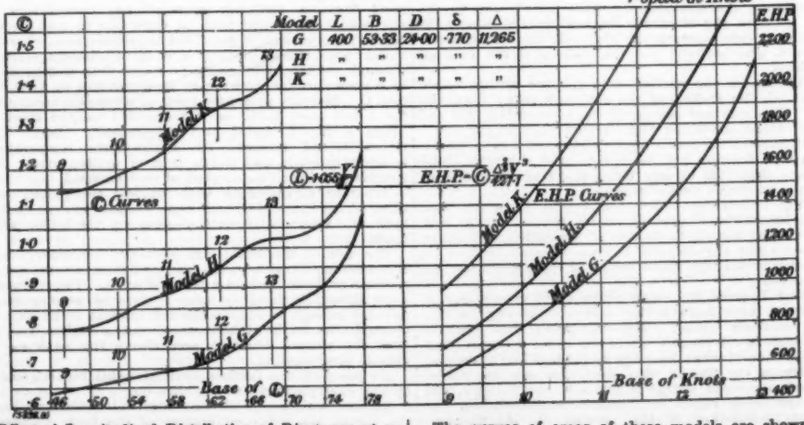


Fig.6. (C) *Curves for 400 Ft. Length and E.H.P. Curves of Vessels corresponding to Models G.H.K.*

L-Length in Feet
B-Breadth in Feet
D-Draft in Feet
δ-Block Coefficient
Δ-Displacement in Tons.
V-Speed in Knots



Effect of Longitudinal Distribution of Displacement on Performance.—The longitudinal position of the centre of buoyancy in the better of these two models was much farther forward than that of the original design. The results obtained led to the consideration of the effect of the longitudinal distribution of displacement in full forms. A series of three models of 0·77 block coefficient were constantly made, with the longitudinal position of the centre of buoyancy respectively 2 per cent. L forward of amidships, amidships, and 2 per cent. L. aft of amidships in order to discover the effect on resistance of such distribution of displacement. Three other models of finer form, viz., of 0·72 block coefficient, with similar relative positions of the centre of buoyancy, were made. The fuller models are designated "G," "H," "K," and the finer forms "L," "M," "N."

The curves of areas of these models are shown on Fig. 5 above, and Fig. 7, page 754.

In the full series the results (see Fig. 6) very decidedly pointed to the advantage of having a fine run, and were quite in keeping with the findings of the "H" series dealing with varying fullness of run, in Mr. Baker's paper on "Model Experiments on the Resistance of Mercantile Ship Forms," read before this Institution in 1914.

With decrease in block coefficient the influence of the

longitudinal distribution of displacement on result is not so marked (see Fig. 8, page 754), and again our results find corroboration in the "G" series in the paper above referred to.

displacement, and of "L" model with the centre of buoyancy 2 per cent. L. forward of amidships, over the range of practical speeds for vessels of the given proportions and fullness.

DIMENSIONS OF CARGO SHIPS A TO D.

—	Length in Feet.	Breadth in Feet.	Draught in Feet.	Displacement in Tons.	δ.	ϕ_f.	ϕ_a.	β.	Long. Centre of Buoyancy from Amidships.
"A"	400	53·33	24	10,752	0·737	0·747	0·757	0·980	0·25 per cent. L. aft.
"B"	400	53·33	24	11,045	0·755	0·768	0·774	0·980	0·25 per cent. L. aft.
"C"	400	53·33	24	11,337	0·775	0·788	0·796	0·980	0·25 per cent. L. aft.
"D"	400	53·33	24	11,629	0·795	0·807	0·816	0·980	0·25 per cent. L. aft.

TABLE I.—TABLES OF DIMENSIONS, COEFFICIENTS, AND RESULTS OF THE VARIOUS MODELS TO 400 FT. LENGTH.

δ = Block coefficient. ϕ_f = Prismatic coefficient forward, ϕ_a = Prismatic coefficient aft,
β = Mid area coefficient, (C) Values on base of (L),

Where (L) $= 1{\cdot}055 \frac{V}{\sqrt{L}}$ E.H.P. $= (C) \frac{\Delta^{\frac{2}{3}} V^3}{427.1}$.

Length, Ft.	Breadth, Ft.	Draught, Ft.	Displacement in Tons.	δ.	ϕf.	ϕa.	β.	(L) 0.48.	0.50	0.52	0.54	0.56	0.58	0.60	0.62	0.64	0.66	0.68	0.70
400	53·33	17·70	7,714	0·715	0·734	0·735	0·974	0·693	0·697	0·700	0·703	0·714	0·730	0·750	0·766	0·778	0·786	0·790	0·790
	—	19·60	8,624	0·721	0·739	0·742	0·976	0·585	0·688	0·691	0·696	0·704	0·720	0·740	0·758	0·770	0·779	0·784	0·785
"A"	—	21·70	9,642	0·729	0·743	0·750	0·978	0·678	0·681	0·682	0·686	0·696	0·710	0·730	0·749	0·760	0·770	0·776	0·780
	—	24·00	10,780	0·737	0·747	0·757	0·980	0·670	0·672	0·674	0·677	0·686	0·700	0·720	0·740	0·755	0·765	0·772	0·775
	—	26·50	12,050	0·746	0·753	0·766	0·981	0·660	0·662	0·663	0·664	0·673	0·687	0·707	0·729	0·746	0·758	0·765	0·769
400	53·33	17·65	7,896	0·734	0·754	0·756	0·972	0·735	0·740	0·745	0·753	0·768	0·786	0·805	0·825	0·838	0·846	0·851	0·853
	—	19·55	8,827	0·741	0·759	0·761	0·975	0·720	0·723	0·729	0·736	0·749	0·763	0·785	0·803	0·819	0·829	0·835	0·839
"B"	—	21·65	9,870	0·748	0·763	0·767	0·978	0·701	0·707	0·710	0·719	0·730	0·745	0·764	0·784	0·798	0·808	0·815	0·820
	—	24·00	11,034	0·755	0·768	0·774	0·980	0·685	0·691	0·694	0·698	0·709	0·723	0·743	0·764	0·780	0·792	0·799	0·804
	—	26·55	12,332	0·762	0·772	0·782	0·981	0·670	0·672	0·674	0·679	0·687	0·701	0·721	0·743	0·760	0·773	0·784	0·791
400	53·33	17·70	8,160	0·756	0·776	0·778	0·974	0·770	0·777	0·781	0·790	0·805	0·827	0·847	0·863	0·875	0·883	0·890	0·893
	—	19·57	9,033	0·762	0·780	0·784	0·976	0·756	0·762	0·768	0·777	0·791	0·812	0·835	0·852	0·865	0·870	0·878	0·885
"C"	—	21·65	10,182	0·772	0·788	0·791	0·978	0·742	0·748	0·750	0·760	0·775	0·795	0·820	0·838	0·852	0·861	0·868	0·871
	—	24·00	11,352	0·775	0·788	0·796	0·980	0·730	0·733	0·738	0·745	0·760	0·780	0·805	0·824	0·838	0·848	0·853	0·858
	—	26·60	12,694	0·783	0·793	0·804	0·981	0·717	0·721	0·723	0·732	0·747	0·766	0·791	0·810	0·825	0·835	0·840	0·845
400	53·33	17·65	8,330	0·774	0·792	0·798	0·974	0·790	0·798	0·803	0·810	0·826	0·846	0·868	0·885	0·900	0·911	0·921	0·932
	—	19·55	9,304	0·781	0·797	0·803	0·976	0·781	0·790	0·795	0·801	0·815	0·835	0·859	0·878	0·892	0·904	0·913	0·924
"D"	—	21·65	10,387	0·787	0·801	0·809	0·978	0·771	0·780	0·784	0·792	0·807	0·827	0·850	0·868	0·883	0·895	0·905	0·916
	—	24·00	11,630	0·795	0·807	0·816	0·980	0·764	0·771	0·776	0·784	0·800	0·820	0·843	0·861	0·876	0·887	0·896	0·907
	—	26·62	13,006	0·802	0·809	0·882	0·981	0·757	0·763	0·769	0·777	0·793	0·813	0·835	0·854	0·870	0·881	0·891	0·901
400	52·00	17·52	8,084	0·776	0·819	0·766	0·979	0·929	0·945	0·969	1·004	1·050	1·084	1·099	1·104	1·135	1·232	1·325	1·375
	—	19·46	9,038	0·781	0·822	0·770	0·981	0·913	0·927	0·950	0·980	1·020	1·054	1·070	1·078	1·120	1·221	1·305	1·352
"E"	—	21·67	10,104	0·787	0·826	0·775	0·983	0·902	0·914	0·935	0·963	1·004	1·035	1·050	1·064	1·114	1·212	1·292	1·332
	—	24·00	11,296	0·792	0·829	0·781	0·984	0·898	0·910	0·929	0·956	0·992	1·024	1·040	1·057	1·109	1·203	1·281	1·320
	—	26·63	12,630	0·798	0·832	0·786	0·986	0·902	0·914	0·935	0·963	1·004	1·035	1·050	1·064	1·114	1·212	1·292	1·332
400	52·00	18·29	8,159	0·750	0·811	0·721	0·979	0·749	0·753	0·762	0·773	0·787	0·800	0·808	0·817	0·824	0·838	0·860	0·885
	—	20·28	9,121	0·757	0·814	0·729	0·981	0·714	0·719	0·728	0·740	0·753	0·768	0·781	0·794	0·805	0·821	0·843	0·870
"F"	—	22·45	10,198	0·764	0·818	0·737	0·983	0·688	0·691	0·700	0·711	0·725	0·740	0·755	0·769	0·784	0·802	0·828	0·847
	—	24·88	11,402	0·772	0·823	0·745	0·984	0·677	0·680	0·685	0·692	0·703	0·715	0·729	0·744	0·762	0·784	0·812	0·845
	—	27·50	12,747	0·780	0·828	0·754	0·986	0·672	0·675	0·678	0·682	0·689	0·697	0·708	0·722	0·742	0·768	0·800	0·835
400	53·33	17·50	8,061	0·755	0·818	0·724	0·979	0·710	0·716	0·728	0·742	0·758	0·770	0·780	0·790	0·801	0·818	0·835	0·852
	—	19·50	9,012	0·758	0·819	0·727	0·981	0·681	0·689	0·700	0·715	0·730	0·745	0·755	0·768	0·781	0·804	0·827	0·850
"G"	—	21·66	10,076	0·763	0·820	0·732	0·983	0·666	0·670	0·680	0·692	0·705	0·717	0·730	0·741	0·760	0·788	0·820	0·849
	—	24·00	11,265	0·770	0·824	0·740	0·984	0·650	0·655	0·662	0·675	0·686	0·698	0·708	0·718	0·735	0·765	0·806	0·847
	—	26·54	12,575	0·779	0·831	0·751	0·985	0·640	0·642	0·650	0·661	0·674	0·682	0·698	0·694	0·708	0·740	0·795	0·845
400	53·33	17·50	8,061	0·755	0·772	0·770	0·979	0·800	0·805	0·821	0·850	0·875	0·892	0·902	0·925	0·952	0·974	0·986	0·993
	—	19·50	9,012	0·758	0·774	0·772	0·981	0·800	0·805	0·821	0·850	0·875	0·892	0·902	0·926	0·958	0·982	0·995	1·002
"H"	—	21·66	10,076	0·763	0·777	0·776	0·983	0·800	0·805	0·821	0·850	0·875	0·892	0·902	0·928	0·963	0·990	1·005	1·010
	—	24·00	11,265	0·770	0·782	0·782	0·984	0·800	0·805	0·821	0·850	0·875	0·892	0·902	0·930	0·969	1·000	1·018	1·022
	—	26·54	12,575	0·779	0·789	0·791	0·985	0·800	0·805	0·821	0·850	0·875	0·882	0·902	0·934	0·975	1·010	1·030	1·036
400	53·33	17·50	8,061	0·755	0·723	0·819	0·979	1·120	1·120	1·130	1·141	1·155	1·175	1·205	1·252	1·305	1·335	1·366	1·415
	—	19·50	9,012	0·758	0·725	0·821	0·981	1·120	1·122	1·135	1·150	1·169	1·190	1·220	1·265	1·313	1·340	1·378	1·423
"K"	—	21·66	10,076	0·763	0·729	0·824	0·983	1·113	1·139	1·148	1·169	1·190	1·213	1·250	1·295	1·330	1·350	1·380	1·430
	—	24·00	11,265	0·770	0·736	0·829	0·984	1·112	1·155	1·173	1·200	1·218	1·246	1·290	1·339	1·362	1·374	1·398	1·463
	—	26·54	12,575	0·779	0·744	0·835	0·985	1·112	1·186	1·212	1·240	1·255	1·295	1·375	1·403	1·413	1·415	1·422	1·455
400	53·33	17·70	7,533	0·699	0·768	0·660	0·979	0·690	0·690	0·693	0·700	0·713	0·727	0·739	0·748	0·753	0·759	0·764	0·772
	—	19·58	8,422	0·706	0·771	0·668	0·982	0·680	0·680	0·685	0·693	0·705	0·719	0·730	0·740	0·747	0·751	0·760	0·769
"L"	—	21·69	9,416	0·713	0·774	0·676	0·983	0·670	0·670	0·678	0·686	0·698	0·711	0·723	0·732	0·740	0·745	0·753	0·765
	—	24·00	10,528	0·720	0·778	0·685	0·984	0·665	0·665	0·671	0·679	0·690	0·703	0·714	0·722	0·730	0·736	0·745	0·760
	—	26·51	11,770	0·728	0·783	0·696	0·985	0·660	0·660	0·665	0·673	0·683	0·695	0·706	0·714	0·720	0·728	0·739	0·754
400	53·33	17·70	7,533	0·699	0·714	0·713	0·979	0·690	0·690	0·695	0·704	0·716	0·725	0·735	0·741	0·747	0·749	0·750	0·751
	—	19·58	8,422	0·706	0·720	0·719	0·981	0·670	0·670	0·678	0·685	0·700	0·712	0·723	0·732	0·740	0·743	0·745	0·746
"M"	—	21·69	9,416	0·713	0·725	0·726	0·983	0·655	0·655	0·660	0·672	0·687	0·700	0·712	0·722	0·730	0·735	0·739	0·743
	—	24·00	10,528	0·720	0·730	0·734	0·984	0·639	0·639	0·644	0·655	0·670	0·685	0·700	0·710	0·720	0·728	0·773	0·740
	—	26·51	11,770	0·728	0·736	0·743	0·985	0·622	0·622	0·630	0·638	0·654	0·670	0·685	0·699	0·707	0·715	0·725	0·737
400	53·33	17·70	7,533	0·699	0·664	0·674	0·979	0·810	0·610	0·810	0·810	0·812	0·815	0·820	0·823	0·829	0·835	0·843	0·853
	—	19·58	8,422	0·706	0·671	0·768	0·981	0·794	0·794	0·795	0·795	0·798	0·802	0·810	0·820	0·831	0·845	0·859	0·875
"N"	—	21·69	9,416	0·713	0·678	0·773	0·983	0·774	0·774	0·775	0·778	0·781	0·791	0·804	0·819	0·834	0·853	0·873	0·896
	—	24·00	10,528	0·712	0·685	0·779	0·984	0·757	0·757	0·759	0·763	0·770	0·780	0·797	0·818	0·840	0·863	0·890	0·915
	—	26·51	11,770	0·728	0·692	0·786	0·985	0·745	0·745	0·748	0·750	0·758	0·771	0·790	0·817	0·845	0·876	0·908	0·985

DIMENSIONS OF CARGO SHIPS G TO N.

—	Length in Feet.	Breadth in Feet.	Draught in Feet.	Displacement in Tons.	δ.	ϕ_f.	ϕ_a.	β.	Long. Centre of Buoyancy from Amidships.
"G"	400	53·33	24	11,265	0·770	0·824	0·740	0·984	2 per cent. L. ford.
"H"	400	53·33	24	11,265	0·770	0·782	0·782	0·984	—
"K"	400	53·33	24	11,265	0·770	0·736	0·829	0·984	2 per cent. L. aft.
"L"	400	53·33	24	10,528	0·720	0·776	0·685	0·984	2 per cent. L. ford.
"M"	400	53·33	24	10,528	0·720	0·730	0·734	0·984	—
"N"	400	53·33	24	10,528	0·720	0·685	0·779	0·984	2 per cent. L. aft.

In the finer series, however, the lowest (C) values are given by the model with the centre of buoyancy amidships, but there is comparatively little difference between the results of the model "M" with that disposition of

The results of the full series illustrate how unsatisfactory the block coefficient may be as a way of expressing the fullness of ships and using this as a criterion of performance. At a speed of 11 knots for the 400-ft. ship, the power required for the vessel—of exactly the same dimensions and fullness—with the displacement disposed as in "K" model, would require to be 80 per cent. greater than that necessary if the displacement were disposed as in "G" (see Figs. 5 and 6, page 752).

Wake and Thrust Deduction Experiments.—In the discussion which followed the reading of Mr. W. J. Luke's 1910 paper on "Experimental Investigations on Wake and Thrust Deduction Values," it was suggested that the hull efficiency elements were very sensitive to the prismatic coefficient of the after body. These varied so much in the six models under discussion that they afforded an excellent opportunity of finding the effect of the after prismatic on the wake and thrust deduction values.

Two propellers were chosen from those at hand, viz., one of 9·6 in. diameter and unity pitch ratio, and the other 8 in. in diameter and of 1·2 pitch ratio. The particulars of these screws brought up to ship size (*i.e.*, 400 ft. length), are as follows:—

—	Diameter in Feet.	Pitch in Feet.	Pitch Ratio.	Disc Area Ratio.	Number of Blades.
(*a*)	19·2	19·2	1·0	0·5	4 blades
(*b*)	16·0	19·2	1·2	0·375	3 blades

It was known, from former experiments, that moderate variations in pitch ratio had little effect on experimental wake values and that the influence of diameter predominated. The diameters chosen cover any differences likely to occur in practice for screws suitable for the size and type of ship, represented by these models.

The wake fraction as expressed by Froude is $w = \frac{V - V_1}{V_1}$, where V = speed of ship; V_1 = speed of ship − speed of wake; the thrust deduction $t = \frac{R_A - R}{R_A}$, where R_A = augmented resistance; and R = resistance without screws. Hull efficiency $= (1 + w)(1 - t)$ (see Mr. R. E. Froude's paper in Trans. I.N.A. for 1883 and *précis* of same in Appendix II to Mr. W. J. Luke's paper of 1910).

From the results plotted on Fig. 9, page 754, it may be seen (1) that the wake value is sensitive to the prismatic coefficient of the after body. The fullness aft of "G" and "H" of the fuller series agrees very closely with that of models "M" and "N" of the finer series, and the observed wake values are in harmony despite the different block coefficients. It may be observed (2) that the wake values as measured by the smaller screws are greater in amount than those recorded by the screws of larger diameter; the thrust deductions also vary somewhat. Lastly the hull efficiencies associated with the 16-ft. diameter screws are greater than those associated with the propellers of 19·2 ft. diameter.

Constructor McEntee's Results Compared with Those here Given.—The experiments recorded above were carried out in the spring of 1918. In November, 1918, Naval Constructor McEntee (U.S.N.), of the Washington Experimental Tank, read a paper before the American Society of Naval Architects and Marine Engineers entitled "Variations of Shaft Horse-Power, Propeller Revolutions and Propulsive Coefficient with Longitudinal Position of the Parallel Middle Body in a Single-Screw Cargo Ship." The investigations made by him cover, to some extent, the same field of experiment as those recorded above. In brief, these were as follows: Four 20-ft. models were made corresponding to ships of 400 ft. length between perpendiculars, and of 57·3 ft. beam, 26 ft. draught, and 13,137 tons displacement when fully loaded. A prismatic coefficient of 0·788 was chosen as representing about the present practice in cargo carriers of this type. A constant length of the parallel middle body was taken equal to 33 per cent. of the length of ship. This percentage has been found to give about the minimum resistance for the speeds attained in practice for this type of ship.

The parallel middle body was placed at varying distances from the forward perpendicular so as to give a full bow and fine run in the first of the series, changing by successive steps to a fine bow and full run in the last of the four models.

The particulars of the corresponding vessels were as given in the table on the next page.

It was found that the best results were obtained when the middle section of the parallel middle body was placed about 43 per cent. of the ship's length from the forward perpendicular. This gave a longitudinal position of the centre of buoyancy 2·4 per cent. of the ship's length forward of amidships, thus agreeing with the results of "G" model in the series now being submitted.

Investigations to find the hull efficiency elements were also carried out. A small direct-current motor was placed inside each model, being transferred from one model to the other as the experiments with each model were completed. To the end of the armature shaft the propeller shaft was connected by means of a flexible coupling. Measurements of torque and thrust were obtained at various linear and rotary speeds, and measurements of wake, thrust deduction, and propeller efficiency were taken. Constructor McEntee records the wake value in terms of the speed of the ship, whereas the method adopted by Froude—and followed in this paper—is that of expressing the wake fraction in terms of the corrected speed. The Washington results have been so amended and are compared with Clydebank's results on Fig. 9, page 754. It will be seen that the wake values are somewhat higher than those obtained in our experiments, that the thrust reduction values are also greater, and that the resulting hull efficiency values are slightly lower.

These differences in result may have been brought about by either the screw in the one set of experiments

being relatively smaller than those used in the other, or by the relative fore and aft positions of the screw.

In the American experiments the propeller diameter was 16·58 ft., associated with a beam of vessel of 57·3 ft. Peabody's results it appears that such differences in position may account for the variation in results obtained at Washington and Clydebank.

If comparatively small differences in position of

Number.	Length in Feet.	Breadth in Feet.	Draught in Feet.	Displacement in Tons.	δ.	ϕ_f	ϕ_a	β.	Long. Centre of Buoyancy from Amidships.
2,132	400	57·3	26	13,137	0·770	0·910	0·665	0·977	5·4 per cent. L. ford.
2,133	400	57·3	26	13,137	0·770	0·869	0·708	0·977	3·6 per cent. L. ford.
2,134	400	57·3	26	13,137	0·770	0·779	0·797	0·977	0·4 per cent. L. aft.
2,135	400	57·3	26	13,137	0·770	0·738	0·838	0·977	2·2 per cent. L. aft.

Fig. 8. © Curves for 400 Ft. Length and E.H.P. Curves of Vessels corresponding to Models L.M.N.

L-Length in Feet
B-Breadth in Feet
D-Draft in Feet
δ-Block Coefficient
Δ-Displacement in Tons.
V-Speed in Knots.

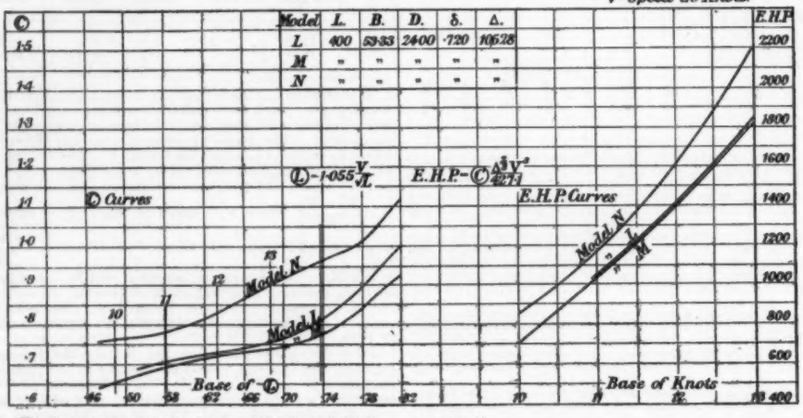


Fig. 7. CURVES OF AREAS OF MODELS L.M.N.

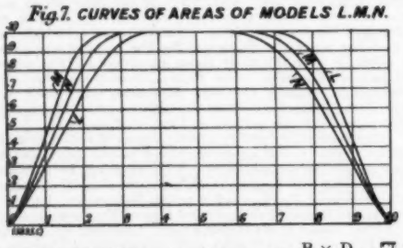
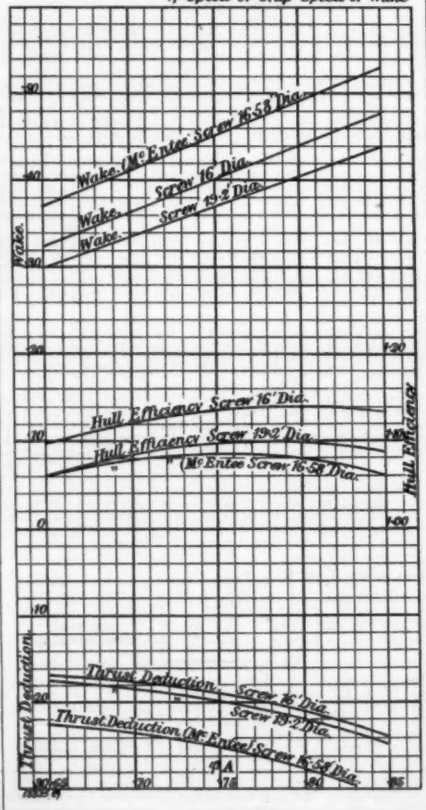


Fig. 9. WAKE, THRUST DEDUCTION, & HULL EFFICIENCY. RESULTS OF EXPERIMENTS WITH SINGLE SCREW.

Diameters given as for 400 Ft. Ship
Speed 11 Knots for 400 Ft. Ship
Wake - $\frac{V-V_1}{V_1}$ where V-Speed of Ship
V_1-Speed of Ship-Speed of Wake



and a draught of 26 ft., in which case the $\frac{B \times D}{diam^2} = \frac{77}{5·4}$.

In the case of our experiments on models "G" to "N" the beam was 53·33 ft. and draught 24 ft.; the ratio $\frac{B \times D}{diam^2}$ with the 16-ft. propeller being 5, and with the 19·2-ft. screw 3·46. The variation in result shown by our experiments between the 16-ft. and 19·2-ft. propeller is, however, too slight to account for any but a small portion of the differences obtained in these separate investigations.

Probably the real reason for the difference is the closer position of the screw to the propeller post of the model in the Washington experiments compared with that possible by the detached screw apparatus method. It may be remembered that Professor Peabody, in his experiments on the self-propelled single-screw model "Froude,"* discovered that the wake and thrust deduction values were very sensitive to distance of propeller from stern-post. The differences he obtained are quite in proportion to those given between our results and those of Constructor McEntee.

The "Froude" was a self-propelled model 37·6 ft. long, and the following results were obtained from varying positions of the propeller from the propeller post at a speed of 6 knots (actual) for the model :—

Distance of Propeller from Stern-post in Inches.	Wake Fraction.	Thrust Deduction.	Hull Efficiency.
1	0·068	0·37	0·68
3	0·123	0·36	0·73
6	0·099	0·18	0·92

In the first position the screw was close up to a relatively broad stern-post and eddies had an effect on the result. As the propeller was moved aft a decided increase in the wake value was followed by a diminution of the same, and the thrust deduction showed even a greater variation in result. In Constructor McEntee's 400-ft. ship the centre of the screw was 2·4 ft. abaft propeller post, which in a 200-in. model would represent 1·2 in., whereas the screw in the Clydebank experiments was 2·4 in. abaft propeller post. From Professor propeller have such a decided influence on the wake value, it is of importance to give some consideration to this point when making choice of a wake value for propeller design.

* See Transactions of the American Society of Naval Architects and Marine Engineers, vol. xix (1911).

Some remarks might be made with regard to the efficiency of the models tried. A close observer may discover some apparent contradictions in the results now submitted. If, for example, the results of models "C" and "H" be compared it will be observed that the © curve for the former is considerably lower than that for the latter, although the longitudinal position of the centre of buoyancy is more favourable for easy resistance in the latter model. The dimensions are alike, and model "C" is a slightly fuller form. This difference is due to difference in form of sectional area curve. In model "C" an easier run aft has been given than that of model "H."

It is perhaps unfortunate that these experiments were not one complete series on the same parent form. On the other hand, some interesting and instructive comparisons may be drawn between the different forms and their results. The writer trusts that the results now presented may be of some interest and value to the members of the Institution, and that some points worthy of discussion may have been raised.

ELECTRIC POWER TRANSMISSION; ACCIDENTS IN SWITZERLAND.—During the year 1918 the "Strong-Current" inspectors of Switzerland received reports of 54 accidents due to electric currents, apart from electric railway accidents. The accidents affected 55 persons; 38 of them proved fatal; attempts to restore life were made in 23 cases, but they were successful only in 2 cases. High-tension transmissions were responsible for 23 of the fatal accidents, and low-tension lines for 15. Attention is drawn to one instance in which the fatality was caused by alternating currents of less than 100 volts; the accident occurred in some electrochemical works and under conditions which are not considered dangerous to life, at any rate. In 19 cases the persons injured belonged to regular working staff; filters suffered more, 27 accidents falling in this category; the remaining 9 cases concern private persons.

QUEENSLAND RAILWAYS.—The report of the Commissioners for Railways, Queensland, for the year ended June 30, 1918, states that several important items formerly imported are now being made in Australia, such as rails and fastenings, linseed oils, white lead, paints. Cement is being obtained from the Queensland Cement and Lime Company's works at Darra, previously it came from New South Wales and abroad. Serge for uniforms is being made by the Queensland Woollen Company at Ipswich. 9,386 tons of rails and 525 tons of fishplates were received during the year under the contract with the Broken Hill Proprietary Company. There were constructed at the State workshops, Ipswich, two class "C. 16" and one class "B. 16½" locomotives for burning coke, besides several carriages and a large number of wagons of different types. Several wagons were also built at the State workshops, Townsville. Four "C. 16" locomotives were built by Messrs. Evans, Anderson, Phelan and Co., and two of the same by Messrs. Walkers, Limited. The State workshops also repaired, overhauled and altered several hundred locomotives and several thousand carriages and wagons.

ODOURS FOR INDUSTRIAL USES.—A restricted use is made of some chemicals of pleasant and unpleasant smells for the purpose of detecting leaks in tests, *e.g.*, of boilers and pipe lines, and for giving a warning of gas escapes otherwise not likely to be noticed. The United States Bureau of Mines recently investigated a number of odours and stenches which might be of use chiefly to give warning in mines. The investigation was conducted by V. C. Allison and S. H. Katz with the aid of an "odorometer." In this apparatus a number of flow meters of the Venturi type are so arranged that a measured volume of air can be passed at a uniform rate over or through the chemical under test, the air-vapour being then mixed with another volume of air also flowing at a uniform rate. From the loss in weight of the chemical and the total volume of air consumed the concentration of the chemical was determined in milligrammes per litre of air or in parts of vapour per million parts of air. The vapour mixture was passed through a rubber tube ending in a funnel; the experimenter placed this funnel over his nose, and decided whether the odour was detectable, faint, quite noticeable, strong, or very strong. Much depends, of course, on the individual experimenter, whose comparative judgment, however, was found reliable. The curves obtained were not all similar; thus it required roughly 10 times as much amyl acetate to make a strong smell as was needed for a detectable smell, whilst the proportions were 1 : 30 in the case of butyric acid and 1 : 5 in the case of mercaptan. The most penetrating smell found was that of artificial musk, which could not, by the method employed, be obtained in concentration of more than 0·00004 milligramme per litre. The nose was also very sensitive to amyl acetate (0·039 milligramme detectable), butyric acid (0·009), propyl mercaptan (0·008), amyl and propyl thioether (0·001 and 0·012), allyl isothiocyanate (0·008), and phenyl isocyanide (0·002). Nitrobenzene with its pleasant smell of bitter almonds was not so readily detectable; ethyl ether (5·8 milligrammes), carbon tetrachloride (4·5), chloroform (3·3), had to be used in much greater concentrations to become perceptible. Though some of these chemicals have unpleasant odours, they are probably harmless in the concentrations in question; nitrobenzene and pyridine are, however, toxic, chloroform and also iodoform are soporific, and some of the cyanogen compounds mentioned are lachrymose and toxic like mustard oil. How the chemicals should be utilised in order to give warning was not discussed in the first communication which Allison and Katz presented to the American Chemical Society.

FATAL STEAM PIPE EXPLOSION.

THE Board of Trade have now resumed the issue of their reports on boiler explosions investigated by their surveyors under the Boiler Explosions Acts, 1882 and 1890, and which have been practically suspended during the war. We have received the report of a preliminary inquiry (No. 2,459) which deals with an explosion of a main steam pipe which occurred on board the steamship Hornby Grange, on August 15 last, while the vessel was lying at Boulogne. The vessel was owned by Messrs. Holder Brothers and Co., Limited, 146, Leadenhall-street, London, E.C., and the pipe which failed formed part of the range of main steam pipes. It was of copper, having a brazed seam and being 4¼ in. in bore. It was fitted with flanges 9½ in. diameter, and the overall length was about 12 ft. 5 in. The report states that the name of the makers of the pipe was unknown, but the pipe was supplied by the engine builders, Messrs. Wigham, Richardson and Co., Newcastle, when the vessel was built in 1890. There was no record of any repairs having been made to the pipe in question. The vessel, including the machinery, was classed 100 A 1 with "Lloyd's Register of Shipping," and the pipe had been inspected from time to time by engineer surveyors to that society. The last inspection was stated to have been made in October, 1911, when the pipes were taken down, annealed, and afterwards tested to 300 lb. per square inch, the test being witnessed by one of the surveyors of Lloyd's Register. The vessel, including the machinery, was insured with Lloyd's and also with several other insurance companies.

With regard to the nature of the explosion, the report of Mr. A. H. Longstaffe, Engineer-Surveyor to the Board of Trade, who made the preliminary investigation, states that the brazed seam of the pipe, which was on the under-side, failed, the fracture commencing at the flange, and extending aft for about 2 ft., the pipe then tearing circumferentially close to the flange until the greatest width of the opening was about 12 in. Through the opening thus formed, steam escaped until it was possible to close the main stop valves. One of the firemen, a man named Peter Johnson, a native of Sierra Leone, was killed. The explosion, in the opinion of the Board of Trade engineer-surveyor, was caused by water-hammer action due to steam being admitted to an undrained section of a range of pipes of which the length that failed formed a part. No drains were fitted to the range.

Under the head of "general remarks" with regard to the circumstances of the explosion, the report states that "the Hornby Grange is a single-screw steel cargo steamer, built by Messrs. Wigham, Richardson and Co. in 1890, steam being supplied at a pressure of 150 lb. per square inch by three boilers, one forward and two aft, the stokehold being between. On August 15 last, the vessel was lying at Boulogne, and steam was being raised in all the boilers preparatory to leaving for London. Mr. W. H. Dibb, the second engineer, stated that on the day of the explosion he went on watch at 4 p.m. The pressure gauge of the two aft boilers showed about 115 lb. per square inch, and that of the forward boiler about 105 lb. per square inch. After noting the pressures he instructed the third engineer to open the intermediate stop valve on the engines, and also the impulse valves, in order to commence warming up the engines. He then proceeded to the boiler tops and opened the whistle valves on the two aft boilers to equalise any variation in the pressures. After waiting a few minutes he eased the stop valve on the starboard main boiler and afterwards that on the port boiler. The stop valve on the forward boiler was not opened. He then opened the starboard main stop valve full, and was in the act of further opening the stop valve on the port boiler, when the explosion occurred. From the time when he commenced opening the valves until the explosion occurred would, he estimates, be about 5 minutes. With the assistance of the chief engineer, who had entered the engine-room on hearing the explosion, the stop valves on both boilers were closed, the boiler tops being accessible by a door from the top platform of the engine-room. After the vapour had cleared away, it was found that the straight length of pipe leading to the forward boiler had failed close to the flange. At the time of the explosion, two coloured firemen, Peter Johnson and Tom Sango, were engaged in opening the bunker door directly underneath the pipe that failed. Sango managed to make his escape to the engine-room by the passage between the starboard boiler and the ship's side, but Johnson was discovered lying between the port boiler and the bunker bulkhead, and when extricated was found to be dead. To get into the position where he was picked up he would have to climb over a fender plate about 3 ft. high and then crawl between the boiler shell and the bunker bulkhead. It can only be surmised that with the sudden rush of steam projecting downwards the unfortunate man lost his sense of direction in his effort to escape."

The report goes on to say that the second engineer stated that he had been on the vessel about four and a half years, having previously held the position of third and fourth engineer. He had never heard any sound indicative of water-hammer in the pipes when opening the stop valves, although he admitted he could never remember opening them under similar conditions, i.e., with the stop valve on the forward boiler closed. At the time of the occurrence the vessel was trimming by the head, and the tendency was for any water in the range to lodge in the forward section. On the return of the vessel to London, suitable drain cocks were fitted, and all the pipes were taken down and tested by hydraulic pressure to 300 lb. per square inch.

It was found, upon a close inspection of the seam where the failure had occurred, that the brazing was defective in several places. The defects were such as might not, under ordinary conditions, have affected the safe working of the pipe, nor is it probable that they would have been revealed by subjecting it to a hydraulic test of double the working pressure. In this instance, however, the pipe received a sudden shock caused by water-hammer action, and the seam was unable to withstand the suddenly-imposed pressure.

The report concludes with some interesting observations by Mr. Thomas Carlton, Engineer-Surveyor-in-Chief to the Board of Trade, as follows:—

"All the conditions favourable to the formation of water-hammer appear to have been present when this explosion occurred, and there is little doubt that the rupture of the pipe was caused by this action. It is astonishing, however, that no means of draining the pipe range were provided, but this omission has been rectified, and the intelligent use of the drains now supplied should prevent a similar occurrence in the future.

"Pipe ranges should never be cleared of water while the boiler stop valves connected thereto are wide open. The drain cocks should first be opened and the boiler stop valves then eased slightly off their faces so as to admit only sufficient steam pressure to the range to blow out all the water of condensation. When the water is cleared away and the range is heated up, the stop valves may be opened—but always slowly—without risk."

POWDERED METALS AND RARE ELEMENTS AS PAINT PIGMENTS.—In two recent publications of the Paint Manufacturers' Association of the United States, circulars Nos. 61 and 62 of the Educational Bureau, H. A. Gardner advocates the use of metal powders and of the rare elements as pigments. There does not appear to be much novel information in circular No. 61, on metal powders; the circular deals chiefly with zinc and discusses the electrolytic troubles likely to arise from the use of metal powders on general lines. The other circular, No. 62, seems more interesting. By rare elements Gardner means not only the generally so-called rare earths, but also elements like selenium, molybdenum, titanium, tungsten, vanadium, uranium, radium and their compounds. Most of these have a high refractive index, and yield hence opaque mixtures of high covering power when ground up with oil. The selenites of lead and barium, Gardner finds, give very white pigments of fine grain. The silicates and aluminates of beryllium and zirconium have similar good qualities, but are more expensive; titanium compounds are already utilised to a large extent. In Aircraft Technique, Note No. 46, of the Navy Department, the same author describes tests of casein glue made by the Forest Service. These glues are supplied commercially in dry powders which are mixed with water, and are considered waterproof in so far as the glue is not subsequently washed out by water. Long soaking makes the glue soft and weakens fabrics, however; but they recover their former strength by drying. The chief drawback of the casein glues is that they set rather quickly, remaining fluid for not more than 5 hours, sometimes only for 2 hours. For aircraft joints the casein glue seems to be preferable to hide glue.

DECAY OF GERMAN TECHNICAL HIGH SCHOOLS.—In view of the agitation for the foundation of a University of Technology in London, attention may be drawn to a memorandum on "The Growth and Decay of Technical High Schools," which was drawn up by Professor A. Riedler a year ago in response to a request for reports on the question by the Prussian Government, and which was published in the *Zeitschrift des Vereines Deutscher Ingenieure* of April 5 and 12, 1919. The Prussian technical high school grew out of trade schools and professional institutions of the middle of the past century, and their development was very rapid after the years 1879 and 1889 when they were given an official status and finally university rank. Professor Riedler, himself late Professor of Engineering at Charlottenburg, Berlin, and a man of influence, took an active share in this development, which did not proceed on the desired lines, however, he now points out. Science, he complains, is confounded with theories, insight with success, constructive ability with its proficiency of the draughtsman; clear conception of principles is neglected, and there is abstracting rather than summarising. Those general disadvantages are the consequence of splitting up and specialisation and of the lack of internal organisation. The different departments of a college stand apart and are themselves divided into sections. The course of studies is too cumbrous and detailed; too much weight is placed on technical specialities and encyclopaedic knowledge. General problems, such as energy changes, fuel utilisation, traffic and transport, national economy, are not adequately dealt with. The war is not directly held responsible for the decay which, Professor Riedler thinks, set in with the beginning of this century. Little will be remedied by joint conferences of representatives of the different departments or of the different colleges; there are far too many committees already. He would not select his advisers from the professional ranks. Something new will have to be built up, not upon the foundations of the old college. Quite aware of the grave character of the innovation he considers necessary, Riedler would make an attempt, limited for the present to a period of three years, to create a new college out of the engineering section of Charlottenburg. His ultimate aim would be union of the technical college with the university, not the separation of the two institutions. At the eighth annual meeting of the Old Students Association of the Royal College of Science last Saturday, the secretary of that association, Mr. T. L. Humberstone, strongly criticised the proposed scheme of a University of Technology, and the duplication of efforts which would lead to endless friction and disorganisation and to waste of public money.

THE TIN INDUSTRY IN THE FEDERATED MALAY STATES.

THE value of the 37,370 tons of tin exported from the Federated Malay States last year was 11,032,234*l.*, which compares with 8,489,610*l.*, the value of the 1917 export of 39,833 tons. In his report on mining in the Federated Malay States in 1918, the Senior Warden of Mines (Mr. W. Eyre Kenny, M.I.C.E.) furnishes some interesting statistics of the tin industry. The Customs record of exports from each of the four States was as follows:—

	1917.		1918.	
	Tons.	Value.	Tons.	Value.
		£		£
Perak	24,643	5,264,215	22,984	6,794,986
Selangor	10,960	2,323,541	10,744	3,171,762
Negri Sembilan ..	734	157,346	625	181,969
Pahang	3,496	744,508	3,017	883,517
Total ..	39,833	8,489,610	37,370	11,032,234

The amount of export duty collected last year was 1,533,240*l.*, compared with 1,102,193*l.* in 1917 and 928,031*l.* in 1916, in both of which latter years the export was larger. The explanation is that duty is paid on a sliding scale based on the price of tin. To the 1918 revenue for duty has to be added 226,192*l.* raised as a war tax by the States for contribution to the Imperial Exchequer. This special surtax was suspended on December 28. Last year the highest price for tin constituted a new record.

The labour force engaged in mining was 144,621 in 1918 compared with 123,340 in 1917 and 139,143 in 1916. Of the 144,621, 34,714 were on contract, 45,840 on wages, 63,224 on tribute, and 843 were individual licensees. There were 189 Europeans employed in the mining industry, the remainder being made up as follows:—

	1916.	1917.	1918.
Chinese	132,053	117,015	135,900
Indians	4,921	4,289	5,966
Malays	1,904	1,774	2,484
Others	68	81	82

The total effective horse-power of plant employed in mining (including 2,542 h.p. at the Rawang Colliery and Raub Gold Mine) was 60,040, and was made up as follows:—

	1916.	1917.	1918.
Steam	24,810	23,748	27,506
Steam-electric ..	4,255	2,420	2,427
Hydraulic	17,911	18,524	18,334
Hydro-electric ..	3,549	4,395	4,512
Suction gas	2,203	1,794	2,219
Oil engines	3,851	2,692	3,171
Oil-electric	1,495	2,003	2,183
	58,074	55,576	60,040

The increase in 1918 was due mainly to the re-employment of idle plant. Difficulty in obtaining plant, spares and stores was greater than in 1917, and though the local Priority Committee rendered every assistance, urgent war considerations had to override local needs. An enterprising Australian Company, with commendable energy, purchased plant in Australia, chartered a steamer, and before the close of the year erection was well in hand. Export of mining plant, except under permit, was forbidden. Fourteen bucket dredges operated in Perak, one in Selangor and one in Pahang; at the close of the year the erection of a seventeenth dredge and the collection of timber for the hull of another was in hand. The total output by bucket dredges was 3,299 tons. Mr. Kenny remarks that the consumption of wire hawsers continued to be high and that the provision of larger sheaves should be considered when new designs are being got out. An American engineer lays down that the diameter of mining sheaves should be at least 40 times the diameter of the ropes, and another authority gives 30 as the minimum proportion.

The progress of the geological survey of the States was interrupted owing to the absence of the Government geologist and his assistant on war service. The employment of a staff of economic mining geologists has been under consideration. In his closing observations, Mr. Kenny says that it has been clearly indicated that the tin deposits in the Federated Malay States are by no means inexhaustible, and conservation of resources is worthy of the gravest consideration, not only with regard to local requirements, but also with reference to the Empire's position in the tin trade.

THE BRITISH SCIENCE GUILD ANNUAL MEETING.—This meeting will be held on June 17, at 4 p.m., at the Goldsmiths' Hall, by kind permission of the Master and Court. Speakers will be: The Right Hon. Lord Sydenham, G.C.M.G., F.R.S. (President of the Guild); Major-General the Right Hon. J. E. B. Seely, C.B., D.S.O., M.P.; Sir Joseph Thomson, O.M. (President of the Royal Society); and Sir Robert Hadfield, Bart., F.R.S. Cards of invitation to the meeting may be had on application to the Secretary, British Science Guild, 199, Piccadilly, W. 1.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

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The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

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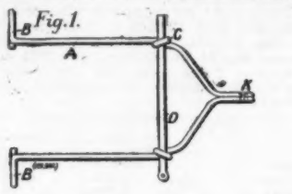
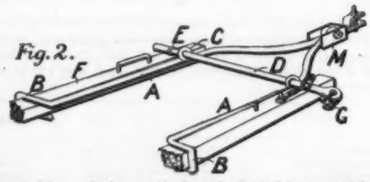
AGRICULTURAL APPLIANCES.

122,962. A. Milsted, Tenterden, and W. H. Judge, Tenterden. Farm Implements. (5 *Figs.*) May 27, 1918.—This invention relates to drawbar means for attaching to tractors farm implements having shafts and originally intended to be drawn by horses. According to the invention, the improved drawbar arrangement comprises two drawbar rods, each of which is bent at its rear end to form a hook adapted to pass around the adjacent shaft of the implement, and is further bent into or otherwise formed with an eye near the front end. A draw-pin passes transversely across the shafts through the eye of an eyebolt secured in the top of each shaft, and through the eye in each of the drawbar rods, thus connecting the drawbar rods to the shafts. This draw-pin is furnished at one end with a safety chain and snap hook or like device, which can be hooked to a staple in one of the shafts, in order to prevent accidental detachment of the draw-pin from the shafts. The front end of the drawbar rods are shaped to come together, and they are

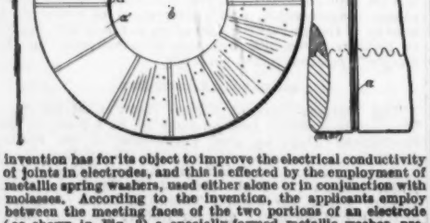




connected by a pin to an attachment adapted to connect to the tractor. A, A are two drawbar rods, each of which is bent at its rear end to form a rectangular-shaped hook B adapted to pass round the adjacent shaft of the implement as indicated in Fig. 2. Each of the rods is bent to form an eye C, through which eyes is passed a draw-pin D. This draw-pin also passes through the eyes of eyebolts E, B, Fig. 2, which are secured to the shafts F, F of the implement, and thus the draw-pin serves to connect the drawbar rods to the shafts. A safety chain G, attached to one end of the draw-pin, is furnished with a snap hook or like device by which it can be hooked to a staple on the adjacent shaft in order to prevent accidental detachment of the draw-pin from the shafts, while allowing of ready detachment when required. The front ends of the drawbar rods are shaped to come together as shown in Figs. 1 and 2, and these ends are formed into eyes K, K through which is passed a bolt to secure thereto an attachment adapted to connect the drawbars to a tractor. (*Sealed.*)

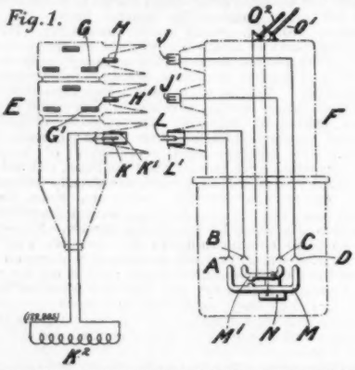
ELECTRICAL APPARATUS.

123,017. C. W. Kayser, Sheffield, and D. W. Macdonald, Sheffield. Electric Furnaces. (3 *Figs.*) September 4, 1918.—The invention relates to electrodes used in connection with electric furnaces, and which are often made up in two or more pieces, the meeting parts being joined together by a threaded screw plug engaging in correspondingly-threaded holes in each part, any spaces between the meeting faces of the threaded portions, and also between the contacting faces of the two pieces of the electrode, being filled in with molasses. The



invention has for its object to improve the electrical conductivity of joints in electrodes, and this is effected by the employment of metallic spring washers, used either alone or in conjunction with molasses. According to the invention, the applicants employ between the meeting faces of the two portions of an electrode (as shown in Fig. 3) a specially-formed metallic washer, preferably, though not necessarily, of copper. This washer consists of a central metallic plate *a* on one or both side of which are secured any desired number of resilient wings *a*1, which may be held in place by riveting, welding, brazing or other suitable means. A central opening *b* is formed in the washer to permit of the passage of the screw plug *c* through it. As shown in Fig. 3, the washer when in use is placed between two portions *d* and *d*1 of an electrode. As the two parts are closed together upon the screw plug *c*, the wings *a*1 of the washer make contact with the meeting faces of the electrode, and if the faces are comparatively even and smooth when screwed up quite tight, the wings *a*1 lie flat against each side of the central plate *a*, and thus give the appearance of a washer composed of three parallel layers. In practice, however, it frequently happens that the meeting faces of the electrodes instead of drawing up face to face all round are rough and uneven, and considerably open at one side, but by reason of the wings *a*1 being resilient and upstanding, they make contact all round between the top and bottom and ensure an effective electrical joint. If desired, however, the air spaces in the joint may be filled in with molasses so as to make a solid construction. (*Accepted February* 19, 1919.)

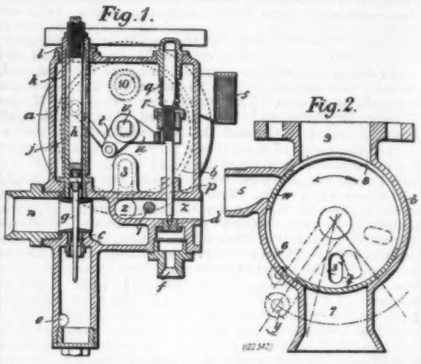
122,885. A. Reyrolle and Co., Limited, Hebburn-on-Tyne, R. M. Longman, Middlesbrough-on-Tees, and H. W. Clothier, Hebburn-on-Tyne. Electrical Switch Gear. (9 *Figs.*) February 4, 1918.—This invention has particular reference to switch gear for use on high-voltage alternating-current systems. Such switch gear is often of the type which comprises a fixed portion having stationary contacts in permanent connection with bus-bars and transformers, and a removable portion comprising an oil break main switch and contacts co-operating with the stationary contacts on the fixed portion. These stationary contacts with the co-operating contacts on the removable portion, form isolating switches. According to this invention, in electrical switch gear of the type referred to, there is combined with the removable portion of the gear, a switch forming part of the main switch gear and controlling a reactance or other apparatus, and an isolating contact for such switch. The drawing represents purely diagrammatically a well-known form of high-tension switch gear of the armoured draw-out type comprising a fixed portion E and a removable portion F. The fixed portion has stationary contacts H and H1 in connection with bus-bars G and G1, and these contacts H and H1 co-operate with contacts J and J1 on the removable or draw-out portion of the switch gear, the contacts J and J1 being connected to oil-immersed contacts D and C in the oil tank. In addition to the contacts H and H1, the fixed



portion of the gear is provided with other contacts K and K1 preferably concentric and connected to a reactance K2. Co-operating with these contacts K and K1 are contacts L and L1 on the removable portion F, these contacts being connected to oil-immersed contacts A and B in the oil tank. The contacts A, B, C and D in the oil tank are provided with suitable switches or circuit-closing members, which may be constructed and operated in any convenient way. As illustrated diagrammatically, the four contacts A, B, C and D are approximately at the same level in the oil tank, the contacts A and D being at the ends of the row and the contacts B and C inside them. The switch for the contacts A and D is shown as a bar M having upturned ends adapted to engage with A and D, and a similar but shorter bar M1 above the bar M is adapted to engage with the contacts B and C. Both bars M and M1 are mounted on a movable insulating member N operated by a rod and handle O1. The shorter bar M1 is pivoted, and is controlled by the hand lever O2. The bar M1 can be moved into two definite positions, one where it is in contact with B, the other end being in contact with C, and the other position where it is in contact with the lower bar M, which itself makes connection between the contacts A and D. In the first position the contacts A and D are connected by the bar M and the contacts B and C by the bar M1. In this position the bus-bars are connected through the reactance K2. In the second position the bus-bars are directly connected together and the reactance K2 cut out. (*Sealed.*)

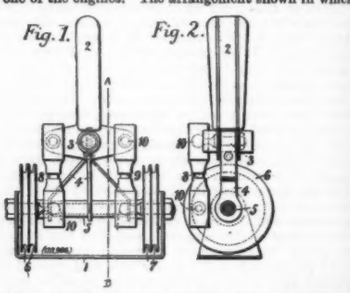
GAS ENGINES, PRODUCERS, HOLDERS, &c.

122,542. C. C. B. Morris, London. Carburettors. (4 *Figs.*) March 12, 1918.—In certain internal-combustion engines which run on both petrol and paraffin bi-fuel carburettors are employed. The subject of the present invention is a carburettor which permits the use of only one kind of fuel at a time, that is to say, the petrol valve is open when the engine is merely ticking round and the paraffin is entirely shut off, the paraffin being admitted when the engine is to run all out, the petrol being then entirely shut off. *a* is the carburettor casing and *b* is the throttle casing. Within the carburettor casing are the paraffin jet *c* and the petrol jet *d*. *e* is the inlet for paraffin from the float chamber (not shown). *f* is the inlet for petrol. *g* is the paraffin-regulating needle attached to the lower end of the spindle *h*. *j* is a guide for the spindle *h*, and *k* is a sleeve working in a nut *l* screwed into the top of the casing *a* and adjustably connected to the spindle *h* by means of a thread. When open, the paraffin jet *c* discharges into the passage *n*, which is connected to a pipe leading to the vaporiser. *p* is the petrol needle having a normal tendency to descend into the jet *d* by reason of the spring *q*. There is a flat cut or thread on *p* to allow the cap *r* to slide freely up and down. *t* and *u* are lever arms fixed on an extension *v* carried by the throttle sleeve *w*. The arm *t* is connected to the spindle sleeve *k*, and operates to raise and lower the paraffin needle *g* when the throttle sleeve is turned. The arm *u* is looped to embrace the petrol needle *p*. When the throttle sleeve is rotated one way, the paraffin needle is lifted and the petrol needle is allowed to descend, and when the throttle sleeve is rotated in the opposite direction the petrol lever is raised and the paraffin needle is depressed, thereby effecting the respective opening and closing of the jets. *x* is an inlet for air leading to the petrol jet. 1 is a screw-pin for regulating the area of the passage through which the air passes. 2 is the outlet for petrol mixture to the port 3 in the carburettor casing, which port is adapted to register with the port 4 in the throttle sleeve in a certain position of the latter. 5 is the inlet port in the throttle from the paraffin vaporiser. The ports in the throttle sleeve are 6 for the cold air entering the casing 7, and 8 which is large enough to open up the inlet 5 for the paraffin



vapour with the induction pipe 9. 10 is an extra air port in the casing *b*, by which additional air may be admitted to a further port in the throttle (not shown). This may be fitted with a hand control on the dashboard for the further regulation of the mixture. (*Sealed.*)

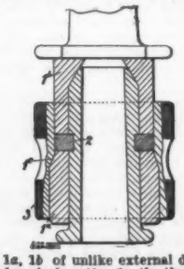
122,996. The Phœnix Dynamo Manufacturing Company, Limited, Bradford, and W. O. Manning, Bradford. Twin Engine Throttle Control. (2 *Figs.*) July 17, 1918. The present invention relates to a method of operating the engine control of twin-engined aircraft and navigable vessels. The present invention relates more particularly to a control arrangement by means of which the controls from each engine are connected to a single operating lever in such a way that by the movement of said lever in one plane, the controls of both engines are moved simultaneously, while by a movement of the same lever in a plane at right angles, the same controls are moved differentially. The control mechanism is mounted upon a support from a 1. An operating lever 2 is pivotally mounted on the pivot 3 carried by a frame 4 rotatably mounted upon a shaft supported in bearings on the main frame 1. At each end of the shaft 5 a pulley 6, 7 is arranged. These pulleys 6, 7 are adapted respectively to take the operating wires from the throttle control of one of the engines. The arrangement shown in which



a pair of pulleys are mounted at each end of the shaft is designed to enable the control to be operated by either of two persons in the manner usual in aircraft, and allows of the employment of a duplicate control, the outer pulley of each pair being connected by wires with the pulleys of the second control. These pulleys 6, 7 are connected respectively through links 8, 9 with lateral extensions of the pivotal end of the operating lever 2. The links 8, 9 are connected with their pulleys 6, 7 and with the operating lever 2, by universal joints 10. The method of operation is as follows: When it is desired to operate the two controls simultaneously the lever 2 is moved with the frame 4 backwards or forwards in the plane of the pulleys, the two connecting links 8, 9 then act as fixed links transmitting the movements of the lever 2 to the pulleys 6, 7. When it is desired to operate the controls differentially, that is to say, to open one throttle and to close the other, the lever 2 is rocked on its pivot 3 in a plane at right angles to the plane of the pulleys and the two connecting links 8, 9 then operate the pulleys 6, 7 in opposite directions. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

122,997. W. Farquharson, Greenock. Drill Chucks. (1 *Fig.*) July 18, 1918.—This invention relates to improvements in drill chucks. A chuck, according to the invention as illustrated in longitudinal section in the drawing, comprises a tubular element adapted to receive a drill or drill holder, said tubular element being constituted by two axially aligned hollow cylin-



drical portions 1a, 1b of unlike external diameter, united by a hollow truncated conical portion 1c, the three openings to receive the three segmental pads 2 being formed in the hollow cylindrical portion 1b of less diameter. The sleeve 3, which telescopes on the tubular element, is formed to mate closely with the tubular element, and comprises two hollow cylindrical portions of unlike internal diameter united by a female conical portion. (*Sealed.*)